SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1902.

GENERAL PHYSICS.

805. 100-*Ton Testing Machine.* **J. H. Wicksteed.** (Inst. Mech. Engin., Proc. 4. pp. 933–938; Discussion, pp. 939–943, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III.) 1901.)—A description is given of a 100-ton universal testing machine recently built for the engineering laboratory at Glasgow University. The machine is of the horizontal type, the weighing system consisting of an L lever, and a horizontal lever with travelling poise. The chief points of interest are the readiness with which the machine can be arranged for tension, compression, shearing, bending, or torsion; a holding nut on the hydraulic ram whereby the load may be maintained on the specimen for an indefinite time, independent of any leak of water; roller stays to guide the weigh-bridge when compressing the blocks during shearing; the use of an auxiliary poise starting from the fulcrum for loads up to 32 tons, during which the larger poise (½ ton) is clamped at the short end of the lever; the wheels of the travelling poises are arranged to form a geometrical slide. Full diagrams are given. H. R. C.

806. *A Pendulum Problem of Euler.* **A. Denizot.** (Deutsch. Phys. Gesell., Verh. 3. 15. pp. 218–220, 1901.)—This paper deals with a problem of Euler's, which is an extension of the ordinary compound pendulum to the case in which the pendulum is rigidly attached to a right circular cylinder supported at its ends on two smooth horizontal planes at the same height, so that this cylinder can move freely on the planes without friction. Euler obtained an approximate solution for the case of small oscillations. The author obtains a solution for finite oscillations in elliptic integrals, giving the time in terms of the configuration of the system. He points out that his solution shows the influence of the cylindrical form of the knife-edge of a pendulum on its period—a problem which Bessel, and recently Helmert, have treated by the use of series. W. S.

807. *Experiments with Vortex Rings.* **A. Indra.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 335–357, April, 1901.)—The author describes a large number of experiments with the well-known smoke ring, the box used having two transparent sides. When a "direct" ring issues from the aperture, a "conjugate" ring enters the box, its rotation being in the opposite direction. Experiments with "direct" rings are described, and show phenomena analogous to reflection, refraction, and absorption. The author gives also a full description of the phenomena observed when several apertures are employed, both when they are and are not in the same plane. He then considers the possibility that vortex rings play a part in the dispersion of storm-clouds by cannon firing, but attributes the effect to sound waves, since the experiments of himself and others show that the vortex rings involved cannot reach a sufficient altitude. W. S.

808. *Range of a Projectile (in Vacuo) on an Inclined Plane.* **A. v. Obermayer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 365–370, April, 1901.)—This is a mathematical paper, in which the author begins by considering the range on a plane inclined at an angle β to the horizontal. The direction of projection is supposed to make an angle α with the inclined plane (or $\beta + \alpha$ with the horizontal), and the velocity of projection is denoted by V. Then if α and V are constant while β varies, the author shows that the locus of the extremity of the range on the inclined plane of angle β, the direction of projection making an angle $\beta + \alpha$ or $\beta + 90^\circ - \alpha$ with the horizontal, is the pair of parabolic paths traversed by projectiles having the same velocity of projection V and initial directions inclined at $90^\circ - \alpha$ or α to the horizontal. The two last parabolas give, of course, the same range on the horizontal plane through the point of projection. Denoting this latter range by R_0 and the range on the inclined plane by R, the author considers for what values of β, R is greater than, equal to, and less than R_0, and gives a tabular statement of the results for a large number of assigned values of α. He then considers certain actual cases in gunnery, and shows that his results explain the rule used in army practice, that to strike a mark considerably above or considerably below the position of the gun, its tilt relative to its platform or "elevation angle" must be smaller than when the range is the same, but the mark on the same level as the gun. Weigner has deduced the same law, taking account of air resistance, and has obtained a general confirmation of his results by experiments with a gun of very short range. W. S.

809. *Determining Small Time Intervals with the Watch.* **R. Etzold.** (Zeitschr. Instrumentenk., Beib. 1. pp. 1–3, Jan. 1, 1902.)—Watches are fitted with a small resonance box of wood to render the beats audible at a distance; the observer has then both hands free. H. B.

810. *An Electrical Tide Indicator.* **L. Y. Schermerhorn.** (Eng. Club Phil., Proc. 19. pp. 82–88, Jan., 1902.)—The apparatus consists of two parts. In the first the rise and fall of a float is utilised to intermittently complete electric circuits, and the currents so produced communicate motion, through the intervention of electric magnets in the second portion of the apparatus, to an indicator arm, through which information concerning the height of the tide is conveyed to the public. The instruments in question are at present working in Philadelphia under the supervision of the United States Coast and Geodetic Survey. Details are fully described in the article in question. W. H. S.

811. *Propagation of a Small Movement in a Viscous Fluid.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 1. pp. 19–35, Jan., 1902.)—The author here uses the results and notation of his former memoir [see Abstract No. 14 (1902)].

Assuming that no external forces act, and neglecting higher orders of the small quantities $\frac{\partial u}{\partial x}$ &c., he obtains (1) the equations of dilatation, and (2) the equations of rotation, so called by Duhem. Clebsch, and other writers after him, had shown how a small disturbance in an isotropic solid can be resolved into two small disturbances, one of dilatation and the other of rotation. The author shows that an analogous proposition exists for the small movements in a viscous fluid, at least in certain cases, and that these cases include that of the viscous fluid discussed by himself. Duhem had shown that the method of Clebsch can be extended to a large class of disturbances, provided that certain conditions are satisfied, which are the conditions of this paper.

The equations of motion are presented in the form—

$$\frac{\partial^2 u_1}{\partial t^2} - (b^2 - c^2)\nabla^2 u_1 + T\frac{\partial}{\partial t}\left(\frac{\partial^2 u_1}{\partial t^2} - b^2\nabla^2 u_1\right) = 0 \text{ ....(1)}$$

for dilatation, and—

$$\frac{\partial^2 u_2}{\partial t^2} + T\frac{\partial}{\partial t}\left(\frac{\partial^2 u_2}{\partial t^2} - a^2\nabla^2 u_2\right) = 0 \text{.........................(2)}$$

for rotation. The equations of motion here obtained are compared with the classic equations for viscous fluid discovered by Navier, Poisson, Stokes, and others. Integrating the equation (2) above given we have—

$$\frac{\partial^2 u_2}{\partial t^2} + \frac{1}{T}\frac{\partial u_2}{\partial t} - a^2\nabla^2 u_2 = A, \text{ a function of } x, y, z;$$

if $f = u_2 -$ Pot $\left(\frac{A}{4\pi a^2}\right)$, where Pot stands for $-4\pi\nabla^{-2}$, this equation assumes the form—

$$\frac{\partial^2 f}{\partial t^2} + \frac{1}{T}\frac{\partial f}{\partial t} - a^2\nabla^2 f = 0 \text{..............................(4)}$$

a generalised form of the "telegraphist's equation." The constant A introduced by this integration is determined. The author then discusses a particular integral of (4); and finally, the effect of using the actual displacements ξ, η, ζ, instead of their derivations u, v, w, when certain constants of the medium are very great, and the viscous fluid becomes what is called a plastic body. S. H. B.

812. *Rock Temperatures at Edinburgh.* **T. Heath.** (Roy. Soc. Edinburgh Trans. 40. 1. pp. 157–186, 1901.)—The readings from May, 1888, to December, 1899, of the four thermometers sunk in 1879 in the Calton Hill rock, at depths of 25, 50, 125, 250 in. respectively, to replace the set provided in 1837 by the British Association, and unfortunately destroyed in 1876, are here tabulated, as also their monthly, quarterly, and annual means; and their readings from 1879, together with the readings of the old set for the forty years of their existence, are discussed in the manner suggested by Lord Kelvin and worked out by Everett in 1860. A difficulty in the discussion arises from the new set having sunk 12½, 10¼, 8½, 1¾ in. respectively since their establishment, owing to the settling of the fine sand with which the bore-hole was filled up and upon which they rest. With the English foot, the year and the degree F as units, the old and new thermometers give respectively 0·1116 and 0·1150 as the value of $\sqrt{(\pi c/k)}$, and thus 252·2 and 237·5 for k/c, and 133·2 and 125·7 for k (with Regnault's value 0·5283 for c for the rock in question). The range R

of temperature at depth p ft. is given by $\log R = 1{\cdot}30103 - 0{\cdot}0485p$, so that the range is 1° F. at depth 26·8 ft. and 0·01° at depth 68·1 ft.; and, on the average, 6·6 days are necessary for heat to pass through 1 ft. of the rock.

R. E. B.

813. *Temperature of the Soil.* **D. A. Seeley.** (Monthly Weather Rev. 29. pp. 501–503, Nov., 1901.)—The author has taken various observations on the temperature of the soil and of the surface at different elevations, in a hilly district near Chicago. Thermometers were inserted to depths of 3, 6, and 12 in. into the bare or cultivated soil; the nature of the vegetation, and even the colour of the grass, have a marked influence upon the evaporation, and hence upon the temperature. He would cultivate the soil early in the afternoon to lessen the danger of night frosts. The paper is mainly of agricultural interest. H. B.

814. *Reduction of Records of Rain Gauges.* **M. S. W. Jefferson.** (Monthly Weather Rev. 29. pp. 499–501, Nov., 1901. Remarks by **A. J. Henry.**)—The author proposes to apply corrections to the readings of rain gauges, and criticises the apparent neglect by the officials of the U.S. Weather Bureau of the influence of topography in constructing rainfall maps. —A. J. Henry, who is in charge of the Records Division, regards the proposal as impracticable, and refutes the criticisms. H. B.

815. *Westward Movement of the Diurnal Barometric Wave.* **O. L. Fassig.** (Monthly Weather Rev. 29. pp. 495–496, Nov., 1901. Paper read before the Milwaukee Convention of United States Weather Bureau Officials, Aug. 27, 1901.)—With the aid of the hourly barometer records of the United States, the West Indies, and also of South America, the author studies the movement of the diurnal barometric wave over the vast area extending from Long. 0° to 140° W., and Lat. 60° N. to 40° S. The charts for the twenty-four hours concern the month of July. This month was selected because the heat equator lies then furthest north, and to eliminate, as far as possible, the influence of the comparative paucity of the southern stations, and of the unequal distribution of land and sea over the two continents. It results that a wave of increasing pressure moves westward over the two continents in the forenoon; it is followed by a wave of diminishing pressure in the afternoon. During the night the distribution of pressure is more uniform, but there is a corresponding secondary period of high pressure in the first half, and of low pressure in the second half of the night, again with a westward movement. H. B.

816. *Isobar Charts.* **W. v. Bezold.** (Archives Néerlandaises, 6. pp. 564–574, 1901.)—In order to map out the distribution of atmospheric pressure, we imagine surfaces of equal pressures, differing generally by 5 mm., and we represent the intersections of these surfaces, either with the gravitational planes, in which case we obtain isobars in the strict sense, or with perpendicular planes, which yield isobars in vertical section. The author discusses the advantages and disadvantages of the two methods, with special regard to the gradient acceleration. The first method is convenient and generally applied. But we often disregard the fact that the density of the air enters into the formulæ, and that the gradient acceleration increases with rising temperature and with decreasing air pressure. This omission may cause errors of as much as 30 per cent. In cyclonic disturbances, the air as a rule rushes

in from the warmer front on the equatorial side, and the air will be less dense along the front of an isobar than at the rear; hence the gradient acceleration will be greater than the gradient would indicate. These disadvantages do not affect the second method, which is, however, too difficult for practical application, and resorted to only in mere diagrams. H. B.

817. *Effect of Magnitude on Time Observations.* **H. G. van de Sande Bakhuyzen.** (Archives Néerlandaises, 6. pp. 727–746, 1901.)—Tables are given of the results obtained by means of a special apparatus constructed to show the variation of the time of perception of moving stars of different degrees of brightness over fine wires. The variation is very strongly marked as the stars approach the limit of visibility. The time of perception increases as the brightness diminishes, and the rate of variation is different for different observers. The probable bearing on the variation of personal equation in transit observations is considered. C. P. B.

818. *Total Solar Eclipse of May* 18, 1901 (*Sumatra*). **H. F. Newall.** (Roy. Soc., Proc. 69. pp. 209–234, Jan. 17, 1902.)—The paper is a preliminary report of the observations made by the party financed by the Eclipse Committee. The programme included photographs of the corona for structure and polarisation, of the spectrum of the chromosphere and corona with prism and grating spectroscopes, and visual observations of the corona for distribution of coronium and polarisation. Much difficulty was introduced into the operations by the presence of clouds, but several valuable records were obtained. The negatives of the corona had scales of standard intensities impressed on them, for the measurement of the coronal intensity at varying distances. Evidences of considerable disturbance are visible in the region near the eastern limb, where there is a well-developed prominence.

All the photographs obtained with the Savart plates show marked polarisation of the corona.

Successful photographs of the chromospheric and coronal spectra were obtained with the objective grating. C. P. B.

819. *Total Solar Eclipse of May* 18, 1901 (*Sumatra*). **F. W. Dyson.** (Roy. Soc., Proc. 69. pp. 235–247, Jan. 17, 1902.)—This expedition from the Royal Observatory was furnished with the same instruments which were employed in Spain, 1900, consisting of a 16-in. cœlostat, 12-in. heliostat, two-prism flint spectroscope, and four-prism quartz spectrograph; also a 4-in. lens. The station selected was on a small island off the west coast of Sumatra. The photographs of the corona were of two classes, large scale for structural detail and small scale ones for recording extensions. Six out of the eight large scale photographs of the corona are good, and the disturbance of the corona near the large prominence is well shown. As most of the photographs were taken through cloud, the spectroscopic results were only partly successful. The spectrum of the corona was recorded from λ5876 to λ3350, with many bright lines, but no absorption. C. P. B.

820. *Total Solar Eclipse of May* 18, 1901 (*Mauritius*). **A. S. D. Maunder.** (Roy. Soc., Proc. 69. pp. 261–266, Jan. 17, 1902.)—The authoress gives details of instruments and exposures employed during the last total eclipse of the sun in Mauritius. Facilities were given for the erection of the apparatus in the Observatory grounds, and by the co-operation of several volunteer helpers,

photographs were obtained with (1) a twin lens camera containing two Dallmeyer stigmatic objectives, (2) a lens of 4 in. aperture and 34 in. focus, (3) a Cooke photo-visual objective of 4½ in. aperture and 71 in. focus, (4) a portrait lens of 2 in. aperture with telephoto attachment giving an equivalent focal length of 8 ft., (5) a pin-hole camera of 30 in. extension.

The photographs with the stigmatic lenses show coronal extensions to five or six lunar radii from the edge of the moon, and the whole of the series of 14 plates exposed with the Cooke lens are good. C. P. B.

821. *Proper Motions of Faculæ in Longitude.* **A. L. Cortie.** (Astrophys. Journ. 14. pp. 317–322, Dec., 1901.)—The author discusses a series of drawings selected from the Stonyhurst records of sunspots and faculæ. For convenience of recognition, a period of minimum sunspot activity is selected, as the various groups of faculæ are then more easily followed from time to time than when the surface is more or less covered with them.

During the year 1889, 121 different groups of faculæ are recorded, 25 of which are associated with spots, and 13 of these have been selected as giving records for periods varying from 120 to 19 days. Their heliographic coordinates have been determined from the original drawings, and the resulting values are given in tabular form. These show distinct evidence of drift in longitude, and reproductions from the drawings which are included in the paper bear out this conclusion. C. P. B.

822. *Declination and Proper Motion of Polaris.* **E. F. van de Sande Bakhuyzen.** (Archives Néerlandaises, 6. pp. 789–824, 1901.)—A discussion of the measures made at Königsberg since 1820 in order to determine the accurate value of the star's position in declination, and to detect if possible any periodical change. Some observations appear to indicate an increase of the declination between 1825–1845, but the evidence is not conclusive; there appears evidence of a minimum near 1875. C. P. B.

823. *Total Light of all the Stars.* **S. Newcomb.** (Astrophys. Journ. 14. pp. 297–312, Dec., 1901.)—An attempt is made to determine practically the total light of the stars by direct comparison of various regions with standard sources. The discs of selected stars were optically enlarged by being viewed through concave lenses, and the resulting patch of light was compared with the brightness of the sky in the neighbourhood. The author concludes that the total light is about equal to that of 600 stars of magnitude 0. Suggestions are given for the construction of a more perfect instrument for future determinations. C. P. B.

824. *Further Researches on the Spectroscopic Double Star Mizar.* **H. C. Vogel.** (Archives Néerlandaises, 6. pp. 661–667, 1901.)—The photographs of the spectrum of the principal star of the well-known double ζ Ursæ Majoris (Mizar) show a varying amount of doubling of the lines, and the author considers that this is evidence of the fact that the star is a binary system, each one of the pair having the same spectrum. This view, previously announced before the Berlin Academy, is further borne out by a series of fifty-five photographs of the spectra taken between March 24th and June 23rd, 1901. The period of rotation of the pair appears to lie between 20·5 and 20·6 days. The relative motions, as calculated from the measurements of the plates, are given, as well as the differences between these and

the values calculated by the Lehmann-Filhe method. The motion of the system relative to the sun is found to be $-14{\cdot}2$ kilometres, as a mean of nineteen measurements. E. C. C. B.

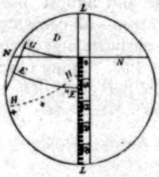
825. *Veramin Meteorite.* **H. A. Ward.** (Amer. Journ. Sci. 12. pp. 458–459, Dec., 1901.)—The author gives a description of this important siderolite, which fell in May, 1880, near Teheran. It now lies in the Palace, and until the present author's visit, there appeared to be no authentic record of its dimensions. Its weight is 113¼ lbs. (51⅜ kilogrammes); in shape it resembles an oblong loaf, 16 in. long, 12 in. wide, and varying in thickness from 7 to 8 in. The whole exterior is covered with the hollow markings usually found on metallic meteorites. When broken, the fractured surface appears as a dull, coarse-grained base or cement, in which large crystallised angular grains are imbedded. The inner constituents have been described as "bronzite"; a green, infusible and almost insoluble silicate, probably peckhamite, and granules of nickel iron—all cemented by a fine network of nickel iron. Possibly there are also enstatite and olivine. The specific gravity of a specimen of the meteorite was 4·57. Stony matter constituted about 42·3 per cent., and metallic matter 57·7 per cent. Of the metallic portion the chief constituents were—$Fe = 92{\cdot}06$; $Ni = 6{\cdot}96$; $Co = 0{\cdot}73$; $P = 0{\cdot}10$; $S = 0{\cdot}15$ per cent. C. P. B.

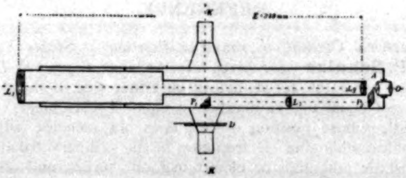
REFERENCE.

826. *Asymmetrical Oscillations round a Position of Stable Equilibrium.* **F. Richarz** and **P. Schulze.** (Archives Néerlandaises, 6. pp. 695–713, 1901.)—Such oscillations occur when the forces acting on either side of the position of stable equilibrium are not equal to one another at equal displacements: for example, in a magnetic needle whose position of rest does not coincide with the magnetic meridian, in Kohlrausch's sine electrometer, in the ordinary balance for measurement of electrostatic potentials or electromagnetic forces, and other cases. The paper contains a mathematical discussion and experimental confirmations. A. D.

LIGHT.

827. *Hammer and Fennel's Tachymeter - Theodolite.* **E. Hammer.** (Zeitschr. Instrumentenk. 22. pp. 21–26, Jan., 1902.)—The instrument is used for determining horizontal distances and differences in level between itself and a vertical surveying pole, one setting only being made, and without reading an angle of altitude or making a trigonometrical calculation. Results of the first trials were published in the above journal in 1900, and the present paper describes the working of the instrument. In Fig. 1, showing the field of view in the telescope, the lines G, EE and HH belong to a photographed diagram, LL is the image of the surveying pole, and NN the cross wire. Tilting the telescope causes the diagram image to pass across the left half of the field, the zero line G always touching NN. Taking the numbers from the figure, the "distance" line EE cuts the pole at 0·14, and the "height" line HH cuts it at 0·08. The constants 100 and 20 reduce these numbers to—Horizontal distance = 14 metres; difference of level = 1·6 metres. Fig. 2 gives a section of the instrument. The diagram D is fixed with its plane perpendicular to the axis KK. The two images are formed by $KP_1L_3P_2AO$ and L_1L_2O, the latter by means of the enclosed Porro telescope. The field of view is halved by the edge of the prism A. The limits, with a 4·4 m. pole, are 300 m. and 60 m. respectively. G. E. A.





828. *A New Interference Spectroscope.* **O. Lummer.** (Archives Néerlandaises, 6. pp. 778–788, 1901.)—This is a simple interference apparatus designed for examining the structure of spectrum lines. Two exactly similar wedge-shaped pieces of glass are taken, and are set against one another, the two long sides together. In this way a parallel slab of glass of variable thickness is obtained. Both wedges are coated with a semi-transparent mirror of silver, and one of them is cemented to a glass plate, while the other is movable by a very delicate micrometer screw; the two wedges are held in contact by a thin layer of oil between them, which further serves as a lubricant. When in use, the rays from the collimator are passed through one or more prisms, and then caused to fall on the interference apparatus, an adjustable diaphragm being interposed to regulate the size of the pencil of light. E. C. C. B.

829. *The Bruce Spectrograph of the Yerkes Observatory.* **E. B. Frost.** (Astrophys. Journ. 15. pp. 1–27, Jan., 1902.)—This instrument, designed especially for line-of-sight work, is of the Keeler type, as described by Hale and Ellerman [see Abstract No. 455 (1900)]. In the construction, special care was taken to keep the following in view: (*a*) rigidity; (*b*) permanence of adjustment; (*c*) freedom from mechanical strain; and (*d*) temperature control. The size of the apparatus was defined by the following optical details: The diameter of the beam of light was fixed at 51 mm., the focal length of the collimator at 38 in., and, for greater convenience, the deviation at 180° for the centre ray. The foundation of the mounting consists of a massive circular ribbed iron casting weighing about 200 lbs. From a point 7 in. from the centre of this, there projects a steel tube 5½ in. in diameter, 28 in. long and ¼ in. thick; this carries the prism casting, which is also secured by six oblique steel braces to the main ring casting. The collimator and telescope tubes are respectively 2¾ and 3¾ in. in diameter; both are accurately fitted with flanges to the prism casting, and the collimator tube is also fastened by a flange to the main ring casting, passing through the centre of it and projecting 9 in. beyond it. There are two cameras and lenses, one of 18-in., and the other of 24-in. focus. These can be easily interchanged by the use of bayonet catches on the prism table, and they are further supported by a bracket from the 5½-in. tube which forms the main support of the prism casting. The whole of this part of the apparatus is made of iron or steel to minimise the strains owing to unequal expansion. Each camera takes plates 2 × 4 in. The slit is of simple construction, with one fixed (but adjustable) jaw. Both jaws are polished, so as to reflect back the light they receive on the surface, according to Huggins' arrangement, but both jaws are independently and symmetrically inclined to the axis of the collimator, and their speculum surfaces make an angle of 185° 47′. The apparatus for comparison work is carried on an additional pillar fixed to the ring casting, and is provided with mirrors, or lenses and prism, for throwing the rays of light on to the slit. It is so arranged that when the comparison spectrum has been obtained, the apparatus can be turned to one side, to allow the beam of light from the great objective to fall on to the slit. For the purpose of guiding the large telescope during stellar exposures, the cone of light reflected from each slit is received by a separate, totally reflecting prism, and by a series of prisms, mirrors, and lenses, the two cones are united and brought to an observing telescope at the back of the spectrograph. In this way a power of nearly 800 is brought into play, and the observer, by means of slow-speed control motors, is enabled to accurately guide the instrument. The whole apparatus is mounted on the telescope tube by a series of eight bolts on the main ring casting, which are simultaneously locked by a lever, a layer of ebonite being used as packing to prevent conduction of heat. The spectrograph is provided with a double-walled aluminium case for keeping the temperature constant, and an electric heater and a fan for keeping the air in circulation are fixed in the case; the temperature is controlled with reference to delicate thermometers placed in various parts of the apparatus. The prisms were a source of trouble at first; three made of Mautois flint, No. 3814, had to be rejected through want of homogeneity. These were replaced by three of Jena dense silicate flint (0·998), with faces 57 × 114, 123 and 133 mm. respectively; angles about 63° 35′, with central ray at minimum $\lambda = 4480$. The mean path of rays in the glass equals 195 mm. Owing to the fact that prisms were moulded, and not cut from cast discs, they are not perfectly satisfactory. In dispersive and resolving power this spectrograph is very similar to the Mills instrument at the Lick Observatory, and to Vogel's Potsdam III. In measuring plates, the wave-lengths of all the lines are calculated by the formula $\lambda = \lambda_0 + \frac{c}{s - s_0}$, three known lines in the comparison spectrum being taken as standards. The wave-lengths, as found, of the comparison spectrum lines are then corrected, and a curve of errors is drawn; corrections are applied from this to the star lines, and, from the new values, the velocity in the line of sight is obtained. A table of measurements of α Arietis is given, showing the small variations obtained on each side of a mean velocity of $-18·66$ kilometres per second. E. C. C. B.

830. *Diffraction Theory of the Microscope.* **J. W. Gordon.** (Roy. Micr. Soc., Journ. pp. 353–396, 1901.)—The Abbe diffraction theory, as stated by Abbe's disciples, is discussed at length in order to show that observation does not uphold the theory, and that further improvement of the resolving power of the microscope is not impossible, but may be looked for, *e.g.*, in the use of systems which expand the wave-front of the light from the object, this being partly done by the use of wide-angled objectives. G. E. A.

831. *Theory of Microscopical Vision.* **J. W. Gordon.** (British Optical Journ. I. pp. 67–69, Nov., 1901.)—This is a reply to criticisms on the author's paper [see preceding Abstract], emphasising the necessity of attending to the diffraction within the instrument, and the prevention of undue contraction of the wave-front at any point. G. E. A.

832. *Axis Error of Crystal Plates.* **O. Schönrock.** (Zeitschr. Instrumentenk. 22. pp. 1–14, Jan., 1902. Communicated by the Physikalisch-Technischen Reichsanstalt.)—The coincidence of optic axis and normal in saccharimeter quartz plates being only approximate, the angle between the two, or axis error, has been measured by Gumlich's method. This, hitherto applicable only to quartz plates over 1 mm. thick, gave an accuracy of about 1′. Brodhun and the author have constructed an apparatus to use with Gumlich's method for quartz plates of ordinary size down to 0·8 mm. thick, the accuracy being to several seconds. The greater part of the paper deals with the development of an expression for the axis error from one for the phase difference of the interfering waves. The method consists in placing the plate between the two Nicols to get the cross and rings. The plate is inclined to the line of vision, and the angle $\phi_1 - \phi_2$ measured, which produces the same displacement of rings as turning the plate in its own plane through 180°. The value of the axis error is then determined from the expression—

$$(\phi_1 - \phi_2)/4 \times \cos\phi(2n_0^2 - \sin^2\phi)/(n_0^2 - \sin^2\phi)3/2$$

where $\phi = (\phi_1 + \phi_2)/2$. If $\phi = 0$, the expression reduces to $(\phi_1 - \phi_2)/2n_0$, n_0 being the refractive index of the crystal. The uumbers given for two quartz plates are: axis errors 8′ 43″ and 15′ 25″, the readings varying within 7 seconds.

G. E. A.

833. *Dispersion of Ultra-violet Rays in Transparent Solids.* **F. J. Micheli.** (Archives Néerlandaises, 6. pp. 634–640, 1901.)—The effect of temperature on the refractive indices of fluorspar, rock salt, quartz, and calcspar is investigated by a photographic method, the prisms used being surrounded by a heating jacket with quartz windows. The displacement dl of a certain line being measured for a temp. change of about 22° to 100°, the corresponding change in refractive index is calculated from $\Delta n = (a + bl)dl$, where a and b are

constants, and l is the distance of the first line from another of known refractive index. From Δn is calculated the value ΔN for a vacuum. It is found that, for the above substances, the change ΔN increases as l decreases, whether for calcspar, in which ΔN is positive, or for the others, in which ΔN is negative in the visible region. In the latter case, ΔN disappears for a certain small wave-length, about 220 $\mu\mu$ for quartz and rock salt. Tables of corresponding values of λ, Δn, and ΔN are given for the four substances. G. E. A.

834. *Pressure of Light.* **P. Lebedew.** (Ann. d. Physik, 6. 3. pp. 433–458, Nov., 1901. See also Electrician, Nov. 29 and Dec. 6, 1901.)—This is an experimental paper confirming previous results [see Abstract No. 1059 (1901)]. The pressure produced by light is directly proportional to the energy, and independent of the wave-length. A. D.

835. *Constants of Refraction.* **A. Bromer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 929–946, July, 1901. From the Physikalisch-Chemischen Institute der K. K. Universität at Vienna.)—The optical measurements were taken by the total reflectometer of Pulfrich, and several inorganic compounds, hitherto little investigated, were dealt with, *e.g.*, lithium sulphate, magnesium bromide, aluminium bromide, nickel sulphate, osmium tetroxide, gold cyanide, &c. A table of values for 22 such substances is given, containing for each, the density of the solution, the molecular weight of the substance, the index for the C, D, and F lines respectively at stated temperatures, the refraction constant of the solution, and the molecular refraction of the dissolved substance. For the calculation of the refraction constant the formula $(\mu^2-1)/(\mu^2+2)d$ is employed, where μ is the index and d is the density of the solution. It is found, by a preliminary set of experiments upon water at different temperatures and concentrated solutions of aluminium bromide, that this formula gives much greater constancy than either $(\mu-1)/d$ or $(\mu^2-1)/d$. A set of tables illustrating this for a temperature range of about 20° to 50° is given. Four other formulæ for the same expression are cited, but all, for specific reasons, are rejected in favour of the one quoted above. The index of refraction μ was determined by the reflectometer, and the density of the solution either by the Mohr balance or by the pyknometer. To calculate the molecular refraction constant from the refraction constant of the solution, the validity of the Biot Arago law was assumed, and the following expression used: $\frac{m}{q_1}(q_2r_2-q_3r_3)$, where m is the molecular weight of the dissolved substance; q_1, q_2, q_3 are the weights of the substance (free from water), the solution, and the water respectively; and r_2 r_3 are the refraction constants referred to above for the solution and for water respectively. Thus a value of the constant of molecular refraction is obtained for all the substances investigated. From these are derived the constants of atomic refraction for the elements lithium, magnesium, aluminium, chromium, iron, nickel, cobalt, arsenic, rubidium, palladium, cæsium, barium, osmium, gold, mercury, uranium. The true specific gravity, *i.e.*, the ratio of the atomic weight to the atomic refraction, is given, and a comparison with results of Hauke and of Gladstone is given. [See also A. Hauke in the above Sitzungsberichte, 105. 2a. (1896), and Abstract No. 1471 (1899).] J. W. P.

836. *Density and Index of Refraction of Air.* **H. G. Gale.** (Phys. Rev. 14. pp. 1–16, Jan., 1902).—The relation $(n-1)/d=\text{const.}$, given by Gladstone and Dale, when $n=$ refractive index, and $d=$ density, is, for gases,

practically the same as that of Jamin, viz., $(n^2-1)/2 =$ const., or Lorentz's: $(n^2-1)/(n^2+{}^2)d =$ const., since n is, for gases, very nearly unity. A concise summary is given of the experimental tests of the accuracy of these expressions for solids, liquids, and gases, together with a very full bibliography. Substitution of the constant A, of Cauchy's equation $n = A + \frac{B}{\lambda^2}$, for n seems to give good general agreement with any of the forms, while Lorentz's form holds well for many substances through the liquid into the gaseous state. The work done on air not being entirely conclusive, experiments are made using an interference method, the air pressure being measured by applying the inverse principle of the McLeod gauge. Two beams of light pass in parallel through pressure tubes, one of which contains the air tested, and the number of fringes which pass on reducing the air gradually to atmospheric pressure is counted. The additional number to zero pressure is calculated and added, and the results go to show that, if there is any departure from the Gladstone and Dale law up to 20 atmospheres for air, it does not amount to more than 0·1 per cent. G. E. A.

837. *Michelson's Interferometer Curves.* **J. C. Shedd.** (Phys. Zeitschr. 3. pp. 47–51, Nov. 1, 1901.)—The author obtains an equation of the second degree for the interference curves given by Michelson's interferometer, and discusses the various conditions under which the corresponding conic section is a hyperbola, parabola, ellipse, circle, or a pair of right lines. The theoretical grounds are given of the method previously described [see Abstract No. 1056 (1901)] of obtaining the chromatic fringes (zero position). The effect of turning the compensator is also discussed, and the resulting motion of the fringes is shown to afford a simple test for its parallelism with the corresponding plate of the interferometer. W. E. T.

838. *Electron Theory of Light.* **W. Voigt.** (Ann. d. Physik, 6. 3. pp. 459–505, Nov., 1901.)—Hertz modified the general electromagnetic equations by an extended definition of electric polarisation. The theory of the propagation of light in ponderable bodies thus obtained has recently received a fresh impetus from the electron-hypothesis. The author applies the new method to a theoretical investigation of the changes in the optical properties of ponderable bodies produced by mechanical and thermal deformations. Absorption is here considered, and the theoretical conclusions compared with the experimental results of Pulfrich and others. Further papers on dispersion and absorption of mixed or compound bodies are indicated. D. E. J.

839. *Rapid Group-Flashing Lights.* **A. Brebner.** (Proceedings of Section 2 of the International Engineering Congress, Glasgow, pp. 190–198, 1902.)—In order to overcome the difficulties connected with the single beam or double beam apparatus combined with an eclipser, which cuts off all the light simultaneously, the author proposes to use a complete subdivided eclipser of two or more parts, each movable independently of the others, along with an optical apparatus of two or more sides. This system requires a screen of two parts for a bilateral apparatus, and so on. With the aid of the complete subdivided eclipser the power of the lightning-light group-flash can be much increased. W. H. S.

840. *Lamp for Light Treatment.* **S. Bang.** (Elect. Rev. 50. p. 117, Jan. 17, 1902.)—Ordinary arc lamps are not expressly constructed for richness

in ultra-violet rays. The author uses electrodes, such as iron, suitably cooled down. It is almost exclusively the arc between the electrodes that emits radiation. The bactericidal power of this lamp is sixty times that of the usual arc lamp, and five minutes at 1 metre is enough to produce erythema of the skin which lasts several days. A very small lamp (5 amperes, 40 volts) produces as much effect at 1 to 1½ cm. in three to five minutes over an area of 10 sq. cm. as the usual apparatus (60 amperes, 50 volts) in seventy-five minutes, but uses only 1/56 as much energy. A. D.

841. *Kerr Effect in Insulating Liquids.* **W. Schmidt.** (Ann. d. Physik, 7. 1. pp. 142–175, Dec., 1901. Extract from the Göttingen Thesis.)—The chief results of this investigation as to the electro-optical phenomena in question may be briefly summarised thus: (1) The determination of the electro-optical constants may be determined by the compensation method for good and bad insulators to an accuracy of from 2 to 20 per cent.; (2) the dispersion phenomena accompanying the double refraction is different in different substances; (3) the electro-optical constant is considerably influenced by the temperature; (4) this constant, for mixtures, so far as investigated, cannot be derived from any simple law; (5) the moderate value of the constant for water is noteworthy, in view of its other extreme physical and chemical properties. Still more striking is the very high value of the constant for nitrobenzol, being of the order of sixty times that for carbon disulphide. E. H. B.

842. *Dispersion of Magnetic Rotation of Polarised Light in Water.* **L. H. Siertsema.** (Archives Néerlandaises, 6. pp. 826–833, 1901. Communicated by the Physik. Institute, at Leyden.)—Eleven series of measurements of the dispersion were made between the limits $\lambda = 4050$ and $\lambda = 7010$; three series were carried out with an apparatus containing one prism, and a wire cylinder 30 cm. long, with 1,107 turns; the tube containing the water was 55 cm. long and 45 mm. in diameter. The ends, closed with parallel glass plates, were sufficiently removed from the influence of the magnetic field. The tube was also wrapped in cottonwool to guard against temperature effects. The final eight series were made with a much larger apparatus, with the water tube 231 cm. long, set inside wire cylinders with 3,650 turns. Three prisms were here used, giving a total dispersion of 14°. The current used was about 60 amperes, and was measured with a galvanometer. The author discusses the accuracy of the experiments, and eliminates certain sources of error, by readings taken with different positions of the Nicols. The position of the telescope could be read to 0°·01. All the results were plotted on a curve, and required very little smoothing. The smoothed results are given, and the differences between these and the actual observed values are given in eleven columns, one column for each series of experiments. These differences, though sometimes over 1 per cent., are usually less than 0·5 per cent. Both sunlight and the arc were used as sources of light. E. C. C. B.

843. *The Klinkerfues Experiment.* **H. Haga.** (Archives Néerlandaises, 6. pp. 765–772, 1901.)—In repeating this experiment a plane grating spectrometer was employed, and was so set up that the collimator pointed due south. An electric arc was placed due south of the slit, and the rays on their way to the slit were first reflected east by a right-angled prism 1, and then reflected back again, west, by another prism, 2, and finally reflected into the slit by a prism 3. Between the prisms 1 and 2, and 2 and 3, an absorption cell

containing bromine vapour could be placed. If these two positions be called I and II respectively, it follows that, were Klinkenfues' idea true, that the earth carries the ether with it round the sun, the effect produced by placing the cell at I at midday and II at midnight would be different from that produced by having the cell at I at midnight and at II at midday. The experiment was tried by examining the relative positions of the sodium lines from the arc, and three bromine absorption lines between them. No difference whatever could be detected, and therefore the author concludes that, if there be any effect, it must be less than one-thousandth of the distance between the two D lines. Klinkerfues claimed to have obtained an effect of 0·0455 tenth metre. E. C. C. B.

844. *Spectrum of Lightning.* **E. C. Pickering.** (Astrophys. Journ. 14. pp. 367–369, Dec., 1901.)—The article describes the interesting photograph of the spectrum of a lightning-flash, which was fortunately obtained with the Draper telescope of 8 in. aperture, provided with a large objective prism, in July, 1901. As there is no definite comparison spectrum, the recognition of the lines is only approximate, and a table of probable wave-lengths is included. An excellent reproduction of the photograph accompanies the article. C. P. B.

845. *Diffraction of Röntgen Rays.* **P. Walter.** (Phys. Zeitschr. 3. pp. 137–140; Discussion, pp. 140–143, Jan. 1, 1902. Paper read before the 73 Naturforscherversammlung at Hamburg.)—This is an account of the results obtained by the author during a repetition of Haga and Wind's experiments [see Abstract No. 1871 (1899)] on the subject. Greater care was taken to secure the apparatus from vibration, and by the use of a special form of tube, homogeneity of the rays was aimed at. By using a greater amount of energy, the exposure of the plate was reduced from 200 hours to about 5 hours. As a final result, no diffraction was observed. In the discussion which followed, **C. H. Wind** criticised some of the author's conclusions as to the homogeneity of the rays used, pointing out that equal hardness in two cases does not necessarily imply that the two streams are homogeneous, either on the hypothesis that the rays are waves of short length, or on the ionic theory. R. S. W.

846. *Absorption of Röntgen Rays by Aqueous Solutions.* **R. K. McClung** and **D. McIntosh.** (Phil. Mag. 3. pp. 68–79, Jan., 1902.)—The absorbing power of different solutions was compared by the following method: Two metal plates kept at different potentials were arranged parallel to each other, and the X-rays allowed to pass between them. Thus a current is set up between the plates, which will be proportional to the intensity of the rays, provided other conditions remain the same. If the current which passes between the plates is measured for different intensities of rays, a direct comparison of the intensities is obtained. The potential gradient which was employed between the plates was about 70 volts per cm., and the current passing was measured by means of a quadrant electrometer. In this way the relative amounts of rays which pass through different solutions were ascertained. The permeability of any given substance was found to be the same for rays of different intensities. An increase in the amount of salt in solution produced an increase in the absorption of the rays. These, however, are not directly proportional, but from the form of the curves showing the variation of absorption with density of solution, the relation appears to be a logarithmic

one. These results agree with those previously obtained by Blythswood and Marchant [see Abstract No. 827 (1900)]. The list of chlorides of various metals investigated, arranged in order of increasing absorbing power, the solutions all having the same density 1·06, is as follows: Sodium, magnesium, calcium, potassium, ammonium, hydrogen, manganese, copper, zinc, barium, strontium, cadmium, mercury, lead. The absorption in the case of different salts depends on two factors, the kation and the anion. As a rule, increase of atomic weight is accompanied by increase of absorption. The results obtained agree in general with those arrived at by previous investigators.
J. J. S.

847. *Colouration Produced by Röntgen Rays.* **G. Holzknecht.** (Deutsch. Phys. Gesell., Verh. 4. 2. pp. 25–28, Jan. 24, 1902.)—Goldstein has described the colouration produced in various salts by the action of kathode rays [see Abstract No. 1311 (1901)]. Similar effects are obtained with ultra-violet light, with the radiation from the electric discharge through gases, and with the radiation from radio-active substances. The author, in the present paper, describes how he has obtained similar changes of colour in different salts of the alkali metals, through the action of Röntgen rays. J. J. S.

848. *Radiographic Equipment for Field or Base Hospitals.* **J. Hall-Edwards.** (Roentgen Ray, Archives, 6. pp. 81–89; Discussion, p. 89, Jan., 1902.)—The author points out that the somewhat sanguine expectations entertained at the beginning of the South African War, as to the benefits to be derived from radiography for the localisation of bullets and shell fragments and the diagnosis of wounds, have not been fully realised, owing mainly to difficulties arising from lack of previous experience. The great value for the saving of life has, however, been conclusively demonstrated, and all such obstacles can and will be removed in the near future. The radiographic apparatus supplied to several hospitals consisted of a 12-in. coil with separate condenser and platinum contact breaker, two "lithanode" accumulators, a Mackenzie-Davidson localising couch, a cross-thread localiser, a fluorescent screen, and all the required accessories, and was quite satisfactory. It was found useless to depend on accumulators sent ready charged from a distance, owing to their handling in transit. Primary batteries for charging the accumulators were found to be useless. A bicycle type foot-motor and dynamo were tried for charging, but no one could be found with strength to work it. The author advises the use of an oil engine, which, for hot climates, should be capable of using heavy oil. This means confining localisation work to the base and general hospitals. A small portable set of radiographic apparatus, nevertheless, might be used in field hospitals with great advantage, not for the definite localisation of bullets, but for a preliminary investigation, enabling the surgeon to discover whether the case is light or serious. The author suggests that, when using the triangulation method in connection with the Mackenzie-Davidson couch and the cross-thread localiser, the two exposures should be made on separate plates instead of on one, which would prevent the first image being obscured by a subsequent exposure, and permit, if desired, an appeal to the Wheatstone stereoscope. The latter should, in his opinion, be included in every base-hospital equipment. Many sets supplied remained unused from the absence of medical officers trained to use them. G. G.

HEAT.

849. *A Viscosity Thermometer.* **A. Job.** (Comptes Rendus, 134. pp. 39–41, Jan. 6, 1902.)—Barus and Callender have suggested [see Abstract No. 814 (1901)] that the viscosity of a gas might be utilised for temperature measurement. Job here describes a method of applying his viscosity apparatus [see Abstract No. 1027 (1901)] in such a way that the variation of viscosity, as temperature changes, shall be made a measure of the change. A 15 per cent. solution of soda is placed in a bottle and corked, there being three holes in the cork—two for the passage of electrodes, and one to allow gas, produced by electrolysis when a current is passed, to escape. This gas is allowed to pass through a porcelain tube of 1 mm. diameter, in which lies a platinum wire 5 cm. long. Thus a very fine annular passage is allowed for the gas. Suppose this porcelain tube is placed in a furnace, the viscosity of the gas decreases and the volume escaping increases. Now the measurement made is not that of the escaping volume, but a much less tedious one, viz., the pressure of the gas on entering the porcelain tube. This is read by a sensitive manometer. To calibrate the manometer, the apparatus is put side by side with any known thermometer. The author has obtained excellent results. *The relation between temperature and pressure is a simple linear one.*

P. E. S.

850. *Tempering of Iron Hardened by Overstrain.* **J. Muir.** (Roy. Soc., Phil. Trans. 198. pp. 1–31, Jan. 23, 1902.)—Steel hardened by overstrain (such as permanent stretching) may have its original properties restored by the usual process of annealing. The author now shows that this may be accomplished, not only at a fairly high temperature, but at any temperature above 300° C. This tempering may be also applied to wrought iron. The experiments were carried out on rods of iron or steel about ⅜ths of an inch in diameter and 11 in. long, the elastic condition of the material being in all cases determined by means of tension tests made with a 50-ton testing machine at the Cambridge Engineering Laboratory, and an Ewing extensometer. The annealing was carried out in a Fletcher gas furnace, 2 ft. long, the specimens being protected from direct contact with the flame by enclosing them in a thick porcelain tube. Temperatures were measured by means of a Callendar's direct-reading platinum-resistance pyrometer. In the case of some samples of steel, a microscopic examination was made, and the processes used for the preparation of the samples are described. A plate showing the structure under the microscope when the samples were etched with nitric acid, and also when stained with cocoa, is of interest. [See also Abstract No. 751 (1901).]

W. W. H. G.

851. *Heat Absorption by Carbonic Acid.* **J. Koch.** (Öfvers. Kongl. Vet.-Aked. Stockholm, Förh. 58. No. 6. pp. 475–489, 1901.)—These researches were made with a view to confirm Ångström's theory. The absorption of radiation from sources at low temperature by carbonic acid strata of varying thickness was tested by Ångström's method, the result being that absorption at first increases rapidly with the thickness of the stratum, while for any considerable thickness, in accordance with Angström's views, it will not vary greatly with further increase. The disagreement with Arrhenius's results is pointed out, and the partial disagreement with Tyndall's data is accounted for. Measurements are given showing the influence of the terminal rock-salt plates. A. G.

852. *Heat Absorption by Atmospheric Carbonic Acid.* **K. Ångström.** (Öfvers Kongl. Vet.-Aked. Stockholm, Förh. 58. No. 6. pp. 381–391, 1901.)—The author maintains his former conclusions [see Abstract No. 807 (1901)] against the criticisms of Arrhenius [see Abstract No. 1907 (1901)], who gives 68 per cent. to 91 per cent. for the maximum, and maintains that it varies greatly with the percentage of CO_2. The author adduces the differences in behaviour of the absorption spectra of water vapour and carbonic acid respectively, as determined by Paschen, Ruben, and Aschkinass, together with his own work on the influence of density on the absorption by carbonic acid, showing clearly that, with increase of density, the amount of absorption will increase much more rapidly than proportionality would require, in support of his own conclusions that the main factor in determining the absorption is the amount of water vapour present. Finally, the author discusses the influence of adding another gas on the absorption spectrum of carbonic acid, the behaviour established by Paschen being another instance in favour of his views. A. G.

853. *Convection of Heat by Air-Currents.* **A. Crichton Mitchell.** (Roy. Soc. Edinburgh, Trans. 40. 1. pp. 39–47, 1901.)—Newton's law of cooling was given by him for a body "not in still air, but in a uniform current of air." This condition has since been generally ignored. From experiments on the cooling of a copper sphere, 2 in. in diameter, in uniform currents of air produced by a Blackman fan, the temperature at the centre of the sphere being measured thermoelectrically, the author concludes that, at least within the limits of 200° C., for temperature-excesses, and 1,000 metres per minute for air-speeds, Newton's law is accurate up to a temperature-excess which increases with increasing speed of the air-current. Thus for temperature-excesses 40°, 80°, 120°, 160°, 200°, the rates of cooling (in degrees per minute) are 8·9, 8·0, 12·0, 16·2, 20·6, for a speed of 271 m. per min., but 8·9, 17·8, 26·7, 35·6, 44·5 for a speed of 1,031 m. per min. Now the loss by radiation depends on a power of the temperature-excess greater than 1, but its ratio to the loss by convection greatly diminishes as the air-speed increases, so that, if the loss by convection is proportional to the temperature-excess, the whole loss will follow this law more approximately, the greater the air-speed. Curves are given showing the variation of the rate of cooling, at a given temperature-excess, with the air-speed. The law of dependence seems to be approximately that of simple proportion, up to the speed of 450 m. per min., which is about that when the air-motion becomes turbulent. R. E. B.

854. *Heat of Formation of Chlorine Hydrate.* **de Forcrand.** (Comptes Rendus, 133. pp. 1304–1306, Dec. 30, 1901.)—Two methods are available for measuring this quantity, the first by direct experiment, the second by calculation from the dissociation curves of the hydrate. The heat absorbed by the solution of chlorine hydrate in water was found by Le Chatelier to be 14, and the heat of solution of gaseous chlorine 3 calories. The resulting value for the heat of formation of chlorine hydrate is 17 calories—

$$Cl_2 \text{ gas} + nH_2O \text{ liquid} = Cl_2nH_2OAq \; . \; . \; . + 17 \text{ cal.}$$

This value, however, is doubtful, as Berthelot found from 2·94 to over

6 calories for the heat of solution of chlorine; the author proves that these irregularities are not due to production of the hydrate. This compound, which is prepared in presence of excess of water, and at temperatures between 2° C. and 5° C., is a paste which contains from eight to twenty times more uncombined water than hydrate of chlorine; this water contains small amounts of dissolved chlorine. Assuming the formula of the hydrate to be $Cl_2 7H_2O$, the total amount of chlorine present as hydrate can be found, and also the true heat of solution. The mean of three experiments gives this as $-15{\cdot}63$ calories; on adding the heat of solution of chlorine gas $+2{\cdot}94$, the value of the formation heat of the hydrate is found to be 18·57 calories. By calculations from the dissociation curves of chlorine hydrate, as found by Isambert, Roozeboom, and Le Chatelier, the mean value 18·06 calories is obtained; this is subject to a correction for the vapour tension of the water produced, which brings the value to 18·16 calories. The number obtained by direct experiment is 18·57, and the mean 18·36. The equation is—

$$Cl_2 \text{ gas} + nH_2O \text{ liquid} = Cl_2nH_2OAq + 18{\cdot}36 \text{ calories.}$$

The author will publish a further paper on the exact composition of the hydrate. W. C. B.

855. *Specific Heats of Electrolytes in Solution.* **W. F. Magie.** (Amer. Phys. Soc., Bull. 2. pp. 23–24, 1901.)—Thomson found the specific heats of many aqueous solutions not to agree with the Joule-Woestyn law. This may be supposed to be due to dissociation, as he only examined electrolytes, and the law of mixtures has been found good for many non-electrolytes. However, the supposition that the solvent retains its specific heat unchanged, and that each of the undissociated and dissociated parts of the solute possesses a constant specific heat, is found to lead to a negative specific heat for the dissociated portion. Therefore it is assumed that a portion of the solvent, proportional to the degree of dissociation, reacts with the dissociate solute, so that its freedom, and therefore its specific heat, is diminished. The resulting formula for the heat capacity, $\phi = Ms + m\sigma - nk$, in which M and m are the masses, s and σ the specific heats, of the solvent and solute respectively, n is the degree of dissociation, and k a constant, is verified for all the solutions tried with the single exception of potassium nitrate. [See also Abstract No. 2125 (1901).] W. E. T.

856. *Compressibility and Cohesion of Fluids.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 437–448, May and June, 1901.)—By integrating, while T is considered constant, the equation (1) of Abstract No. 622 (1901), and No. 101 (1902), the author deduces $(p + P)(v - a) = T/12{\cdot}225m$ as the equation of state of the fluid, P being a function of the temperature. Considerations are put forward to show that P is the cohesion-pressure of the fluid, and it is suggested that it may be independent of the specific volume, only at temperatures considerably below the critical temperature, *e.g.*, if of the form $\theta(T)\{1 - e^{-\chi(T)/v^2}\}$, it may reduce to $\theta(T)$ for the fluid state, and to $\theta(T)\chi(T)/v^2$ for the vapour state. Stefan, treating the latent heat of evaporation of a liquid as due to the work done (A) in bringing the particles from the interior of the liquid into the surface, and the work done (B) in bringing them from the surface into the vapour space, has pointed out certain assumptions under which A and B are equal. The calculation of P from the above equation allows of this being tested, for $A = Pv$, and $A + B$ can be found

from the value of the latent heat of evaporation. Tables are given showing the results for carbon bisulphide, chloroform, benzine, water and ethyl alcohol. For the first three, at lower temperatures A and B are approximately equal, while for the other two, and for carbon bisulphide at higher temperatures, they are very different; thus, at 0° C. for water, B is 3·694 times as great as A. W. E. T.

857. *Influence of Gravity on the Distribution of Temperature in a Gas.* **F. de Boer.** (Archives Néerlandaises, 6. pp. 641–649, 1901.)—Considering an atmosphere of one kind of molecule, in equilibrium above an immovable earth, and supposing its surface plane, gravity not to vary with height, and no interchange of heat by conduction or radiation to occur, and that, if any shock occurs between two molecules which modifies the velocity of a particle, there corresponds at the same moment another shock, by which another particle acquires a velocity corresponding to the former velocity of the other particle, the author shows that t/δ^2 is constant for the various layers, and that $3p = \delta(v^2 - 2gh)$, if the initial velocity (v) of a particle rebounding from the earth is the same for all, and if, among the initial velocities, all directions in space are equally represented. If the initial velocities are not supposed equal, Maxwell's law of distribution is shown to lead to the temperature being independent of the height, and to be the only one which is the same throughout if the temperature is the same throughout. A possible law of distribution is also given without the assumption of constant temperature being made, and the laws are extended to gaseous mixtures. W. E. T.

858. *Temperature of Inversion of the Joule-Thomson Effect for Hydrogen.* **K. Olszewski.** (Akad. Sci. Cracovie, Bull. 9. pp. 453–459, Dec., 1901.)—At − 78° C. hydrogen is slightly warmed, and at − 83° C. it is slightly cooled, on expansion from 117 atmospheres to 1 atmosphere without doing work, the temperature of inversion seeming to be − 80·5° C., which agrees well with the temperature − 79·3° C. deduced from the formula by which Rose-Innes represents the results of Thomson and Joule: hence, for the liquefaction of hydrogen by the Hampson or Linde method, we need not employ a stronger cooling agent than solid carbonic acid mixed with ether. For the temperature of inversion for air, the Rose-Innes formula gives 360° C.; and if we take − 140° C. for the critical point of air, the theory of corresponding temperatures gives − 232·6° C. for the critical point of hydrogen, that experimentally found by the author being − 234·5° C. R. E. B.

859. *Velocity of Flow of Crystallised Substances.* **G. Tammann.** (Ann. d. Physik, 7. 1. pp. 198–224, Dec., 1901.)—According to the hypotheses of Poynting and Ostwald, the relation between temperature and pressure for a two-phase one component solid-liquid system varies according as the melt can or cannot flow freely away. Thus, according to these views, ice will melt, provided the water can escape, at much lower pressures than those corresponding to its ordinary pressure-temperature equilibrium curve. The author tests these views by measurements of the plasticity of ice, phosphorus, naphthalene, and piperine. The substance was contained in a steel cylinder of narrow bore closed at one end by a screw, and was pressed down by a small plunger. Pressure was communicated to the plunger by a rod actuated by a lever, and as the plunger sank into the substance, the latter was squeezed upwards, between the sides of the plunger and the cylinder, into an open

space above. Varying weights were hung at the end of the lever-arm, and the rate of sinking of the plunger was measured by following the motion of a point on the lever-arm. This was done by screwing down a metal piece which closed the circuit of an electric bell when it touched the lever. When melting occurs, the plunger suddenly sinks as far as possible. The hypotheses of Poynting and Ostwald were disproved. It was found that the melting-points so obtained for ice corresponded to the pressures in the manner indicated by the ordinary pressure temperature curve for ice-water. In the case of ice and white phosphorus, the plasticity increases very rapidly with the deforming force and with the temperature, while in the case of naphthalin and piperin (both crystallised and amorphous), there exists, for certain temperatures, a *maximum* of plasticity with increasing pressure. The author criticises the theoretical considerations advanced by Poynting and Ostwald, and concludes that there is no valid theoretical argument in favour of the existence of the second melting-point curve. F. G. D.

860. *The Equation of State of Gases and Liquids as a Power Series.* **H. Kamerlingh Onnes.** (Archives Néerlandaises, 6. pp. 874–888, 1901. Communicated by the Physik. Institut at Leyden.)—The series development—

$$pv = A + \frac{B}{v} + \frac{C}{v^2} + \frac{D}{v^4} + \frac{E}{v^6} + \frac{F}{v^8}$$

is applied to combine the measurements of Ramsay and Young and of Amagat on ethyl ether. The coefficients A, B, &c., are termed *virial coefficients*, and are functions of the temperature. The above expression can be transformed into—

$$\lambda p'v' = A' + \frac{B'}{\lambda v'} + \frac{C'}{\lambda^2 v'^2} + \frac{D'}{\lambda^4 v'^4} + \frac{E'}{\lambda^6 v'^6} + \frac{F'}{\lambda^8 v'^8},$$

where p' and v' now denote *reduced* pressure and volume, and λ is a coefficient determined by the critical data. The coefficients A′, B′, &c., are termed the reduced *virial coefficients.* Virial coefficients calculated from Ramsay and Young's measurements on ether at 0° C. (liquid-vapour equilibrium), combined with Maxwell's criterium, are found to reproduce Amagat's measurements of the compressibility of liquid ether at pressures varying from 200 to 8,100 atmospheres, with very considerable accuracy. It is also found that the reduced virial coefficients can be expressed as temperature polynomials of the form—

$$B' = b_1 t + b_2 + b_3 \frac{1}{t} + b_4 \frac{1}{t^3}$$

$$C' = c_1 t + c_2 + c_3 \frac{1}{t} + c_4 \frac{1}{t^3} \quad \&c.$$

Thus the complete behaviour of a substance, both as gas and liquid, can be expressed with very considerable accuracy by means of 25 constants. The temperature-coefficients of the reduced virial coefficients for different substances possess a specific character. In order to bring different substances into line, these temperature-coefficients are altered so that the behaviour of each particular substance is represented within the limits of experimental accuracy, and so that the special reduced virial coefficients for various substances agree at a temperature lying far beyond the region of observation. Tables showing this are given. F. G. D.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

861. *Theory of Electrions.* **Kelvin.** (Archives Néerlandaises, 6. pp. 834-861, 1901; and Phil. Mag. 3. pp. 257–283, March, 1902.)—The author propounds a modification of the one-fluid theory of Electricity of Æpinus according to which this fluid is made to consist of minute equal and similar atoms, which he calls *electrions*, smaller than the atoms of ponderable matter, and capable of permeating freely both the atoms and the spaces between them. The atoms are assumed to be spherical, and, as in the theory of Æpinus, repulsion is assumed between atoms and also between electrions, with attraction between atoms and electrions outside of them; and both repulsions and attractions are assumed to follow the law of inverse squares, in accordance with the researches of Cavendish and Coulomb. As a tentative hypothesis, it is assumed that the attraction experienced by an electrion entering an atom undergoes no abrupt change, and decreases to zero simply as the distance from the centre when the electrion, approaching the centre, is within the spherical boundary of the atom, as would be the case if the electric virtue of the atom were due to uniform distribution through the atom of an ideal electric substance of which each infinitely small part repels infinitely small portions of the ideal substance in other atoms, and attracts electrions according to the law of inverse squares. Corresponding suppositions cannot, however, be made for the force between two overlapping atoms; for freedom must be reserved for the addition of an attraction or repulsion, according to any law of force that may be found convenient for the explanation of electric, elastic, and chemical properties of matter. The neutralising quantum of electrions for any atom or group of atoms has the same quantity of electricity of one kind as the atom or group has of the opposite kind.

For a single atom this quantum may or may not consist of an integral number of electrions, *e.g.*, the molecule of a diatomic gas might conceivably have an odd number of electrions for its quantum, in which case the single atoms of the gas, if capable of separate existence, would necessarily be electrified. The author infers from experimental results, such as Varley's discovery [Proc. Roy. Soc. 19. pp. 239–40, 1871] of the molecular torrent of resinously electrified particles from the kathode in highly exhausted tubes, that the electrions must be considered as resinously electrified, and a void atom, therefore, as a little globe possessing as an essential quality vitreous electricity uniformly distributed through it or through a smaller concentric globe; and that ordinary ponderable matter, not electrified, consists of a vast assemblage of atoms, not void, but having, within the portions of space which they occupy, just enough electrions to annul electric force for all places of which the distance from the nearest atom is large in comparison with the diameter of an atom or molecular cluster of atoms. The author first considers the conditions of equilibrium of the electrions in the case of one atom approaching another until they overlap, and ultimately become concentric. If the two atoms are polyelectrionic, the remarkable result is arrived at that, after separation, the number of electrions in the smaller atom will be increased, and that in the larger decreased, which would explain the origin of electrification produced by pressing together and then separating two solids. The author suggests that this may probably be the explanation of the fact that ground glass is resinous relatively to polished glass, as the process of polishing might be expected to smooth down the smaller atoms, and to leave the larger atoms more effective in the surface; and also of E. Murray's discovery that burnishing metallic surfaces, previously cleaned with emery-paper, makes them more positive in the Volta Scale [see Abstracts Nos. 1065 and 1341 (1898)]. The author discusses various possible stable configurations of electrions within an atom, and many interesting problems are indicated, after which he shows that these hypothetical atoms realise perfectly, for sparse assemblages, Faraday's suggestion [Experimental Researches, § 1679] of "small globular conductors, as shot," to explain the electro-polarisation which he discovered in solid and liquid insulators. It is suggested that the hypotheses here put forward seem to open the way to a very definite detailed dynamics of electrolysis, of chemical affinity, and of heat of chemical combination. If, however, we were tempted to assume further that all chemical action is electric, and that all varieties of chemical substance are to be explained by the numbers of electrions required to neutralise an atom or set of atoms, then, since all the electrions are assumed to be alike, it would be necessary to postulate different laws of force between the different atoms. On the electrionic hypothesis, a solid would, at the absolute zero of temperature, necessarily be a perfect insulator of electricity under the influence of electric forces sufficiently moderate not to pluck electrions out of the atoms in which they rest stably when there is no disturbing force, but, as the temperature rises, electrions will be shot out of their atoms, and, if in an electric field, there will be a resultant travel in the direction of the electric force, thus explaining the increase of conductivity of bad conductors with rise of temperature. To explain the conductivity of metals on the same principles, it is only necessary to assume that metallic atoms are so crowded with electrions that the latter are always being spilt out of each atom by intermolecular and electrionic thermal motions, not only at ordinary atmospheric temperatures, but even at temperatures as low as 16° above the absolute zero, as it was in the neighbourhood of this temperature that Dewar found [Bakerian Lecture on Nadir of Temperature, June, 1901] that various metals have still very high conductivity, and it is quite easy to conceive that, with rising temperature, the electric conductivity may reach a maximum and then decrease; for, while some thermal motion is necessary for conductivity, too much of such motion must impede the freedom with which an electrion can thread its way through the crowd of atoms to perform its function of electric conduction. The paper concludes with illustrations of the applicability of the author's hypotheses to the explanation of the phenomena of the pyro-electricity and piezo-electricity of crystals, including examples of the possibility of producing the octo-polar electric æolotropy of Haüy in a homogeneous assemblage of tetra-electrionic atoms. G. W. de T.

862. *The Theory of Electrons and Electric Resistance in a Magnetic Field.* **E. van Everdingen, Jr.** (Archives Néerlandaises, 6. pp. 294–302, 1901.)—This paper deals with the electron theory of conduction in metals. J. J. Thomson has worked out [Paris Congress Report, 1900] an increase of resistance in bismuth in a magnetic field. The author has revised the calculation, arriving at the unexpected result that the irregular movements of the electrons would cause, on the whole, a diminution of resistance, and

prevent the magnetic force from producing the Hall effect. This is modified by the electric fields between the electrons and the comparatively stationary charged ponderable particles, which would probably bring about the observed results. Further research is being carried on. A. D.

863. *Automatic Registration of Atmospheric Discharges.* **J. Fényi.** (Comptes Rendus, 134. pp. 227–228, Jan. 27, 1902.)—A coherer, consisting simply of two crossed pieces of metal, is placed in series with a coil, at the centre of which is suspended a mirror carrying a magnetic needle. A clockwork or bell encloses the coherer, and by its vibrations, when a current passes, causes decoherence. A fraction of a volt is found to give the best results. When a lightning-flash occurs, coherence takes place, and the mirror is deflected. Very good automatic records have thus been obtained during the past year. R. S. W.

864. *Ascending and Descending Air-Currents and Atmospheric Electricity.* **F. Linke.** (Ann. d. Physik, 7. 1. pp. 231–235, Dec., 1901.)—In the "normal" condition of the earth's electric field the earth possesses a negative charge, and consequently positive charges must be regarded as present in the atmosphere. The presence of those positive charges has recently been explained on the ionic theory; according to Ebert's measurements [see Abstract No. 1917 (1901)], the positive ions in the atmosphere are more numerous than the negative, the excess of positive and also the total number of ions decreasing upwards. The author considers that this theory is incompetent to explain the high potential differences occurring in connection with the phenomenon of lightning, and shows that a satisfactory explanation of this and other phenomena of atmospheric electricity is given by the motion in the earth's field of clouds and layers of vapour. The principle used is that when a conductor, having a charge Q and capacity C, is in electrostatic equilibrium at a place where the potential is V, then, when it moves to a place where the potential is V′, a quantity of electricity $C(V - V')$ becomes "free" and disturbs the field. This principle, along with the effects of induction and coalescence of drops, explains how the high potential differences required for lightning are the effect of rapid air-currents. The author has verified his assumptions by observing the state of the same cloud at different levels during a balloon ascent. W. S.

865. *Atmospheric Electricity at Zakopane.* **A. Witkowski.** (Acad. Sci. Cracovie, Bull. 1. pp. 7–10, Jan., 1902.)—Observations made in August and September, 1901, in the large and shallow valley of Zakopane, north of the Tatra Mountains, at an altitude of 850 m. The collector electrodes contained a few mg. of radio-active barium chloride; the indications of these electrodes were identical with those of flames, and more stable. Exner's potential maxima of 8 a.m. and 8 p.m. were well accentuated; his sudden rise of potential at the moment of sunset was observed a few times (120 volts maximum), not as a rule. Negative and positive charges were dispersed with equal rapidity. On the Swinica, however, at an altitude of 2,000 m., the negative charges disappeared much more rapidly (ratio 15·5 : 4·5). H. B.

DISCHARGE AND OSCILLATIONS.

866. *Electric Discharge in Gases.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 3. p. 129, Jan. 1, 1902.)—A T-shaped tube contains a kathode at either end of the cross-piece, one of them being plane and the other concave. A single anode is inserted at the end of the other branch. At comparatively high pressures the luminosity is the same in both ends of the branch containing the kathode; a reduction of the pressure causes all the discharge to go to the plane kathode. By placing the finger in the neighbourhood of the concave kathode all the discharge is diverted to it, but immediately springs back on the finger being removed. The luminosities near both kathodes are also equal when an equal number of striæ occur in their respective branches. Should the same number not be present, there is a considerable difference in the luminosities. R. S. W.

867. *Electrical Discharge in Wide Vessels.* **O. Lehmann.** (Ann. d. Physik, 7. 1. pp. 1–28, Dec., 1901.)—The author describes and gives the results of a number of experiments undertaken with the object of ascertaining what alterations take place in the character of the electrical discharges through rarefied gases, when, for the narrow tubes commonly used, spacious receptacles are substituted. Those here employed consisted of two large bell-shaped air-pump receivers cemented together. The form of the discharge then shows that the conditions are much simpler than with the customary narrow tubes and small electrodes. The normal form, which is maintained throughout—even if the strength of the current is such as almost to form an arc—is the glow discharge, characterised by the absence of the so-called positive column of light. The kathode is surrounded by three strata, the first a seam of yellow light, while the anode is enveloped by a film of pinkish positive glow-light. At a suitable pressure of air, an e.m.f. of not more than 360 volts suffices to maintain the discharge, and the dark space attains a thickness of 30 cm. and more. Figures obtained experimentally show that, provided the air pressure remains unaltered, the thickness of the dark space of the kathode section decreases when the e.m.f. and currents are increased, and *vice versâ.* Experiments made for the purpose of ascertaining the smallest e.m.f. sufficing to obtain a discharge show that, with low voltages, such as 430, at which a discharge takes place when the air pressure is 0·15 mm., and which remains unaltered even when the current is increased from its minimum value of 3·5 to 7 milliamperes, the stoppage of the current does not, under the circumstances described, raise the potential, as is usually the case, but leaves it unchanged. When a condenser of large capacity is used for supplying the current, and the conducting wires are of low resistance, the discharge at a low voltage appears to be continuous, while, on increasing the voltage, a brilliant display of sparks is witnessed, filling the whole receptacle with a blinding white light. Even at a voltage, however, which hardly suffices to secure the passage of the discharge, and when the latter does not occur spontaneously, though the electrodes are connected with the surfaces of the condenser, it suffices to excite a magnetic field of proper strength, and to place it in a suitable position, to produce brilliant discharges accompanied by a loud crackling noise, quite startling to those who have only witnessed discharges in the ordinary vacuum tubes.

The author in his book on "Discharges," has shown that under certain circumstances, the positive light of the anode can be forced to advance to the limit of the light of the kathode. His more recent researches show that this positive light can even be made to traverse the outer luminous stratum of the kathode until it reaches the dark space, while, when the dark space extends close to the glass wall of the oval receptacle, the anode glow-light can force itself through between the dark space and the glass wall. In the remainder of the experiments described in this paper, the author deals with glow discharges passing through wire nets, the effect of intervening diaphragms, the stratification of the negative light, the interpenetration of two discharges, and the effect of hollow and of concentric electrodes. The author deems the material so far collected insufficient for the explanation of the phenomena, but suggests that, by further experiments it may be possible to ascertain whether, as is assumed in the older theory, the process of discharge consists essentially in a sudden disappearance of the dielectric condition of polarisation, the electric energy being transformed into radiant heat and other forms ("disruptive discharge"), while positive and negative discharges alternate in quick succession, or whether, as is demanded by the newer electron hypothesis, this process represents a combination of two or more open currents of different kinds, which appear simultaneously, and by combination form a closed current, or finally, whether radiancy is merely an accompanying phenomenon, while the current itself passes continually, and without the production of light, through the gas, as through an electrolyte, so that the observed strata and lines exactly represent the underlying reality. In the latter case, the explanation of the polar differences by an accumulation of electrified air, suggested by the author on a previous occasion, would appear to be untenable. G. G.

868. *Discharge of Electricity from Glowing Platinum, and Velocity of the Ions.* **E. Rutherford.** (Phys. Rev. 13. pp. 321–344, Dec., 1901. Paper read at the Denver Meeting of the American Association for the Advancement of Science, Aug., 1901.)—In a former paper [see Abstract No. 2147 (1901)] the author has given a theoretical discussion of the conductivity of gases when the ionisation is confined mainly to the surface of one electrode. The present experimental investigation was made to test the validity of some of the conclusions arrived at. The ionisation is produced by heating the platinum electrode by an electric current. The current passing between this plate and another metal plate parallel to it is measured for various distances between the plates. Theory gives an equation for the current, from which it appears that (1) the current is independent of the intensity of the ionisation—*i.e.*, of the temperature of the plate—beyond a certain limiting value; (2) the current is directly proportional to the square of the voltage between the plates; (3) the current is directly proportional to the velocity of the ions, and inversely as the cube of the distance between the plates.

Testing these by experiment, the author finds that they are not all fulfilled. The variation of current with voltage, and variation with distance between the plates, are in general agreement with theory, if we make due allowance for differences between the experimental and theoretical conditions. But in the case of (1) above, there are wide discrepancies between the experimental and the theoretical results. These are discussed, and the author shows that they may be satisfactorily explained if we suppose that, above a certain temperature, the current is carried by two or more kinds of carriers, some of which move much more slowly than the others. No definite explanation can as yet be given of the origin of these slow carriers, but two suggest themselves as possible. Since glowing platinum is known to lose weight, due probably to disintegration of the surface, the particles shot off might in their passage, slow compared with that of a free ion, acquire a charge from the ions. On the other hand, there is considerable evidence that in the discharge of electricity by flames of glowing platinum, the ions are of unequal size; whether initially unequal, or becoming so from condensation of matter around them, cannot be readily determined by experiment. The author finally discusses the velocity of the ions, and shows that the theoretical values cannot be assumed to represent the actual values. Direct measurement shows that the velocity of the positive ions from glowing platinum may, for given conditions, vary within wide limits; the velocities of the ions increase with increase of temperature of the gas through which they pass; and the values calculated from the theoretical formula are too small. W. C. H.

869. *Decomposition of Hydrogen Peroxide by Light, and Electrical Discharging Action of this Decomposition.* **R. F. D'Arcy.** (Phil. Mag. 3. pp. 42–52, Jan., 1902.)—The author describes experiments showing (1) that hydrogen peroxide when exposed to sunlight is decomposed, and (2) that a layer of hydrogen peroxide undergoing this decomposition is capable of discharging negative electrification. In the case of positive electrification no clear indications were given. The special form of apparatus employed is described. The discharging effect of hydrogen peroxide is compared with that of water, by using these liquids, under identical conditions, in alternate experiments. The author suggests that when hydrogen peroxide is split up into water and oxygen, the water is positively charged and the oxygen negatively, and that the ions normally present in air may have their origin in this chemical action. The formation of H_2O_2 in nature is a recognised fact, and if the origin of the positive and negative ions be due to its decomposition, the phenomena of atmospheric electricity might be traced to the action of plants, assuming the correctness of the view that to their action is to be attributed the free oxygen of the atmosphere. W. C. H.

870. *Spontaneous Ionisation of Gases.* **C. T. R. Wilson.** (Roy. Soc., Proc. 69. pp. 277–282, Jan. 31, 1902.)—The author gives the results of measurements of the relative rates of production of ions in air and other gases, when contained in a closed vessel, and not exposed to any known ionising agent. The apparatus used was practically the same as that described in the author's earlier paper [see Abstracts Nos. 849 and 1507 (1901)], in which his discovery of this spontaneous ionisation was published. Measurements were made for air, hydrogen, carbonic acid gas, sulphur dioxide, and chloroform. The curves indicating variation of saturation-current with pressure show that, except at the higher pressures, the leak is proportional to the pressure. For those pressures at which the straight-line law holds, and where the rate of leak is a measure of the ionisation, the author gives the following table of "relative ionisations":—

Gas.	Relative Ionisation, Spontaneous.	$\frac{\text{Relative Ionisation}}{\text{Specific Gravity.}}$	Relative Ionisation, produced by radium rays (Strutt).
Air	1·00	1·00	1·00
H_2	0·184	2·7	0·157
CO_2............	1·69	1·10	1·57
SO_2............	2·64	1·21	2·32
$ChCl_3$.........	4·7	1·09	4·39

Thus, except in the case of hydrogen, the ionisation is very nearly proportional to the density of the gas. The values of this relative ionisation occurring spontaneously show a remarkable similarity to those obtained by Strutt [see Abstract No. 1646 (1901)], for the same gases when exposed to the action of radium rays (see last column of above table). The author thinks that an explanation of the results may be found if we suppose the ionisation to be due to a slight radio-activity of the walls of the containing vessel, the radiation being of only moderate penetrating power. The departure from the straight-line law at higher pressures would thus be explained, as at these higher pressures the intensity of the radiation might be reduced by absorption before reaching the centre of the vessel. Further experiments, however, are needed before a definite conclusion can be drawn, that the spontaneous ionisation is due to radio-activity of the walls. W. C. H.

871. *Phosphorus Emanation.* **C. Barus.** (Phil. Mag. 3. pp. 80–91, Jan., 1902.)—In this paper the author concludes his series of papers on the behaviour of phosphorus emanation. [See Abstract No. 58 (1902).] The experiments here described have as their object the determination whether the assumption previously made that, with the conditions chosen (swift-air currents, and highly sensitive ioniser), the decay of the ionisation might be disregarded. For this purpose spherical condensers are used, so that no ions can escape, and the results show—on the whole—that decay due to mutual destruction of ions is not in direct evidence, and may be considered negligible in these investigations. The enclosed air at a distance from the phosphorus rather behaves as if it contained more ions than the number reaching it from the source. The paper ends with a summary of the theory underlying all the investigations. W. C. H.

872. *Determination of Frequency of Slow Electric Vibrations.* **K. E. F. Schmidt.** (Ann. d. Physik, 7. 1. pp. 225–230, Dec., 1901.)—This method is characterised by the use of a telephone to generate stationary acoustic waves in a glass tube. The telephone is excited by the vibrations under examination, and the acoustic waves thus formed are detected and measured by Kundt's dust figures, and also by the lengths which give sounds of maxima and minima intensity. With frequencies of 2,800 an accuracy of 0·1 per cent. was obtained. E. H. B.

873. *Skin Effect in Electrical Oscillators.* **C. A. Chant.** (Amer. Journ. Sci. 13. pp. 1–19, Jan., 1902.)—An account is given of elaborate experiments undertaken to find whether electrical oscillators with very thin surfaces of metal are as efficient as similar ones made solid or with thicker skins. Oscillators of the cylindrical and of the spherical type were used. The cylindrical oscillators were 2·5 cm. in diameter and 12·5 cm. long, the ends being hemispherical. The materials used were respectively solid brass, solid Norway iron, copper tubing 1·5 mm. thick and 0·8 mm. thick, solid electric light carbon, sheet platinum 0·0018 cm. thick on a wooden form, sheet silver 0·002 cm. thick, tinfoil 0·0025 cm. thick on wood, gold leaf 0·0000114 cm. thick on wood, silver leaf 0·00003 cm. thick on wood, copper deposited electrolytically to thicknesses 0·0001, 0·00015, 0·0002, and 0·0005 cm., silver deposited chemically on glass to a thickness of 0·000013 cm. The spherical oscillators were of the Righi pattern. The oscillator spheres were of three sizes, viz., 2·5 cm. in diameter, 4 cm., and 10 cm.; each size was made in solid brass and in gold leaf on wood. The receiver used was a Rutherford magnetic detector. The results are exhibited in seven tables, and show that, in the case of the cylindrical and spherical doublets, the various thin mantles, and even the excessively thin gold-leaf shells were as efficient as the solid metal bodies. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

874. *Dielectric Constants of Dilute Electrolytic Solutions.* **A. de Forest Palmer, Jr.** (Phys. Rev. 14. pp. 38–56, Jan., 1902.)—The author describes experiments on comparing the dielectric constants of dilute electrolytic solutions (copper sulphate and potassium chloride) with that of pure distilled water. A pair of Leyden jars on insulating stands have their outer coatings connected to a spark-gap and induction coil, their inner coatings to a pair of parallel copper wires of about 8 metres in length, on which a wire bridge is arranged to slide. Two identical quadrant electrometers of the cylindrical type have one pair of quadrants, the needle and brass case connected together, and to a point on one of the wires about 2¼ metres from the inner coating of the Leyden jar; the other pairs of quadrants, which are insulated from the case, are also connected together, and to a point on the other wire equidistant from the coating of the jar to which it is attached. The electrometers are respectively filled with the solutions to be compared. When the coil is in action the frequency of the Hertzian vibrations is about 10^6 per second, and the needles of the electrometers are deflected, the amount of the deflection being controlled by the position of the wire bridge. The spots of light of the electrometers are then brought to their zeros, by turning torsion heads to which the needles are attached (the zero position being the ones in which the needles are symmetrically situated with regard to the quadrants), and the induction coil stopped, the resulting deflections observed, and from these deflections can be deduced the ratio between the dielectric constants of the two solutions used. The results obtained show it is highly probable that the dielectric constant of dilute electrolytic solutions, of conductivity less than $2{\cdot}5 \times 10^{-4}$ ohms per centimetre cube is the same as that of pure water in fields varying at the rate of 10^6 oscillations per second. E. C. R.

875. *Variation of the Dielectric Constant of Caoutchouc by Stretching.* **G. Ercolini.** (N. Cimento, 2. pp. 297–301, Nov.–Dec., 1901.)—According to theory, if the electrical deformation of a condenser is such that its internal volume and its length increase, then the dielectric constant of the solid isotropic dielectric should increase when it is subjected to mechanical tension. For glass the author has previously [see Abstract No. 464 (1899)] shown this to be the case, but with caoutchouc, Corbino and Cannizzo [see Abstract No. 571 (1899)] found that stretching causes a diminution of the dielectric constant. The results of these last-named workers are, however, indecisive, since the author now finds that, like india-rubber [see Abstract No. 2142 (1901)], caoutchouc also undergoes strong electrification when stretched.

T. H. P.

876. *Thermoelectric Power of Steels and Nickel-steels.* **G. Belloc.** (Comptes Rendus, 134. pp. 105–106, Jan. 13, 1902.)—This is a continuation of previous work on soft iron and steel [see Abstract No. 2217 (1900)], with an extension to nickel-steels containing from 5 to 35·5 per cent. of nickel. The result is that the (dE/dt, t) curve has a minimum about 380°, a maximum between 660° and 870°, depending on the composition, and another minimum about 120° above the maximum. H. Le Chatelier has found similar results in the variation of resistance with temperature. For the nickel-steels the curves do not progress with the chemical composition as with the steels; the general form of the (E, t) curves for nickel-steel platinum couples is parabolic excepting that for the 5 per cent. nickel; the 5 and 28 per cent. nickel-steels showed sudden variations above 400° and 500°, pointing to some molecular change; the 28 per cent. nickel-steel has great thermoelectric power and high neutral point; and small variations in the amount of nickel cause large changes in thermoelectric power, as shown in the table below:—

Percentage of Nickel.	Neutral Temp.	E in Microvolts at 196° to 400°.
5	—	—
24	250	980
26	60	70
28	495	6,300
30·4	95	120
34·6	190	1,050
35·2	84	112
35·5	150	616

G. E. A.

877. *Measurement of Potential.* **C. Carpini.** (Accad. Lincei, Atti, 11. pp. 65–69, Jan. 19, 1902.)—The paper contains a discussion of the method of measuring high potentials by observing the deformations of a liquid surface (mercury in tubes of known diameter). The results obtained are very favourable. A. D.

878. *Hall Effect in Liquids.* **P. Moretto.** (N. Cimento, 5. pp. 80–84, Jan., 1902.)—The alkalimetric method previously used with success in studying the Hall effect in solids [see Abstract No. 2032 (1900)] is extended to the investigation of the Hall effect in liquids. Negative results were obtained throughout, even with bismuth amalgam. A. D.

879. *The Induction Coil.* **Rayleigh.** (Archives Néerlandaises, 6. pp. 197–211, 1901, and Phil. Mag. 2. pp. 581–594, Dec., 1901.)—The complications in the theory of the induction coil are due mainly to (1) the departure of the iron from theoretical behaviour, whether due to circumferential eddy-currents or to a failure of proportionality between magnetism and magnetising force; (2) the departure of the break from the ideal of an instantaneous abolition of the primary current; (3) the capacity of the secondary, in virtue of which the currents need not, at any moment, be equal throughout. On the assumptions of ideal iron, instantaneous break, and no secondary capacity, Maxwell has given a complete solution (Scientific Papers, 1. p. 546). Making the first two assumptions, and treating the secondary as a condenser with oscillatory current, let q be the capacity at the secondary terminals, V the maximum p.d., L the coefficient of self-induction of the primary circuit, and c the current in the primary just before breaking. Then the energy of the charge is qV^2, and this can never exceed the energy of the primary current before break, viz., $\frac{1}{2}Lc^2$, so that the limiting value of V is $V = c\sqrt{(L/q)}$, which is proportional to the primary current. When the core is long and narrow, or forms a nearly closed circuit, the behaviour of the iron may differ widely from the ideal. The author arrived some years ago at the conclusion (Phil. Mag. 22. p. 175, 1886) that, on the theory of Warburg and Hopkinson, the bodily magnetisation of the iron does not, as is generally supposed, represent a large store of available energy. If the core is treated as an elongated ellipsoid of revolution, with magnetisation I parallel to its longest axis, due to an external magnetising force H parallel to the same axis, then the demagnetising effect of I will be NI, where N is a function of the eccentricity, and the operative magnetising force H will be given by the equation $H = H' - NI$, and the work

expended in magnetising unit volume of the iron will be $\int H\,dI + \frac{1}{2}NI^2$, reckoning from the condition of zero magnetisation. The first part of this is practically wasted, while the second, which in most cases of open magnetic circuits is much the larger, is recovered on demagnetisation. Taking 1700 c.g.s. as the maximum value of I, the maximum energy, where v is the volume of the core, is $\frac{1}{2}Nv \times 1700^2$, and equating this to $\frac{1}{2}qV^2$ gives (in electrostatic measure) as a limiting value for V, $V = 1700\sqrt{(Nv/q)}$. This gave $V = 2600$ for a coil in the author's possession constructed to give an 8 to 10 cm. spark when new. Reckoning 33,000 volts to the cm., this would give 24 cm. as the calculated limit to the spark-length, and, considering that the limit is fixed by the iron and secondary capacity only, the smallness of its excess over the actual capability of the coil is noteworthy. The effect of suddenness of break is then considered, and it is shown, supposing the behaviour of the iron to be ideal, in which case the secondary circuit may be treated as a simple vibration subject to a force proportional to the rate of fall of the primary current, that a reduction in the number of windings, and the accompanying diminution in the time of oscillation, would necessitate greater suddenness of break, in order to maintain the spark-length. Theoretically it is difficult to see that any advantage can be derived from a condenser, except increased suddenness of break. Except for this effect, the increase of capacity would diminish the spark-length. The author has confirmed these theoretical conclusions by experiments in which the primary circuit was broken with great suddenness by means, first of a pistol bullet, and then of one fired from a service rifle, and it was found that a greater spark-length was obtained in this way than with a condenser, and the addition of a condenser in conjunction with this quick break diminished it. These experiments strongly support the view that the only use of a condenser, in conjunction with an ordinary break, is to quicken it by impeding the development of an arc, so that, when a sufficient rapidity can be obtained by other means, the condenser is deleterious, prolonging, in fact, the decay of the primary current.

The author's conclusions with respect to the design of induction coils are that (1) there should be sufficient energy at break, and therefore a considerable mass of iron, well magnetised, and not forming a circuit too nearly closed; (2) the obstacles to the full utilisation of this energy are want of suddenness in the break, eddy-current in the iron, and (in respect of spark-length) capacity in the secondary; (3) in a well-designed coil these impedimenta should operate somewhat equally. G. W. DE T.

880. *An Absolute Electrometer. Measurement of the Potential of Discharge.* **E. Pasquini.** (N. Cimento, 2. pp. 302–312, Nov.–Dec., 1901.)—The electrometer described in detail by the author is essentially an absolute electrometer with a guard-ring, the measurement of the force of attraction between the fixed plate and the movable disc being made by means of the equilibrium of floating bodies. Results are given of a number of experiments made with the instrument, which yields very concordant numbers. T. H. P.

881. *Volta E.M.F. in Electrometers.* **W. Duane.** (Phys. Rev. 13. pp. 369–377, Dec., 1901.)—The author shows that the Volta e.m.f., due to the contact between dissimilar metals, may introduce considerable error in measurement by electrometers. If, in a quadrant electrometer, V_1, V_2, V_n, are respectively the potentials of the two pairs of quadrants and the needle, the forces of attraction and repulsion will depend on $V_1 + \phi_1$, $V_2 + \phi_2$, and $V_n + \phi_n$, where ϕ_1, ϕ_2, ϕ_n are the rises of potential in passing from the metals to the air just outside. When the electrometer is used heterostatically these Volta e.m.f.'s introduce no error, as they are taken into account in the zero of the instrument. When used idiostatically $V_n = V_1 + \phi_{1n}$ and $\phi_1 = \phi_2$, and for the usual formula must be substituted—

$$\theta = k(V_1 - V_2)\left\{V_1 - V_2 + 2(\phi_n + \phi_{1n} - \phi_1)\right\}.$$

Tests made on an electrometer with brass quadrants and aluminium needle showed a difference of 5 mm. in a deflection of 275 mm. on reversing the e.m.f. After cleaning the needle with emery-cloth the difference was increased to 26 mm. Methods of measuring the effect are described.

G. H. B.

882. *Oscillometer for Measuring the Current and Oscillations in a Secondary Circuit.* **G. Bowron.** (Roentgen Ray, Archives, 6. pp. 11–12, Aug., 1901.)—The discharge from a static machine or induction coil may be more or less oscillating or alternating. The author couples in series a gravity milliamperemeter and a permanent magnet direct-current milliamperemeter ; the former gives the sum of the direct current and the superposed oscillations, the latter their difference.

A. D.

883. *Rectifier.* **G. B. Batten.** (Roentgen Ray, Archives, 6. pp. 12–16, Aug., 1901.)—An armature oscillating between constant and alternating poles actuates a spring which makes contacts, through which pass two alternately interrupted currents. Sparking is prevented through introducing a retardation of phase by a transformer, and accelerating the phase of the driving current by a condenser in shunt across a resistance. The apparatus is self-starting, self-acting, small and compact, and is suited to single-phase alternating machine currents of any voltage and any periodicity.

A. D.

ALTERNATING CURRENTS AND MAGNETISM.

884. *Energy Dissipated in Dielectrics in an Alternating Electric Field.* **P. L. Mercanton.** (Journ. de Physique, 1. pp. 33–39, Jan., 1902.)—Condensers formed by plates of dielectrics to be experimented on of 3 to 4 mm. in thickness were submitted to cyclic changes in the potential difference applied to their terminals, the frequency of which could be varied. Arrangements were made for disconnecting the condenser at any point of the cycle, and discharging it through a ballistic galvanometer. Curves similar to the magnetic hysteresis curve for iron were thus obtained, and the area enclosed by the curve was proportional to the energy consumed in the dielectric. Condensers were formed of plates of pure paraffin wax, with which were incorporated various substances with conducting, insulating, or poorly conducting properties. The following results were obtained, with periodic time = 1 sec. and V_{max} between 63 and 88 volts. The loss of energy was found to be inappreciable in the case of pure paraffin ; of paraffin mixed with 4·7 per cent. of powdered aluminium, 4·4 per cent. of powdered arc lamp carbon, 5·4 per cent. of graphite, 50·0 per cent. of resin, or with 10, 20, or 30 per cent. of sulphur ; Berthoud, Borel & Co.'s insulating compound ; a mixture of dry pine sawdust and paraffin ; a large lamina of white mica 0·10 mm. thick ; paraffin wax containing 50 per cent. of resin, and Berthoud's compound superposed. This last experiment was tried to verify the allegation of Muraoka that two dielectrics, each without hysteresis, produce a residual charge when superposed, but the result was negative.

Various liquids contained in a flat trough into which were plunged metal plates were experimented on. Pure vaseline oil gave no loss, but when mixed with 5·9 per cent. of crude lampblack a considerable loss was observed, the ratio ρ of the throw on the ballistic galvanometer corresponding to zero potential, to the throw when the potential is a maximum, having the value 0·07. For celluloid and window-glass the values of ρ were 0·065 and 0·038 respectively. In the case of paraffin wax containing 1, 2·5, 5, and 9·4 per cent. of lampblack respectively, the values found for ρ were 0·013, 0·073, 0·260, and 0·380. Mechanical vibration of the dielectric while charging made no sensible difference in the loss of energy. Experiments were made on a paraffin wax condenser containing 9·4 per cent. of crude lampblack as to the connection between W, the loss of energy due to hysteresis, and T, the periodic time of a cycle, the values of T being taken from 0·25 sec. to 50 secs. at values of V_{max} 19, 36 and 73·8 volts. In each of the three cases a very marked maximum of W is shown for $T = 3$. When plotted as curves with W as ordinates and T as abscissæ, the curve is asymptotic to the axis of abscissæ for large values of T, and for small values it bends rapidly towards the origin. For $T = 1$ sec., and V_{max} 16·7, 34, and 68 volts respectively. The values of W were $77·5 \times 10^{-10}$, 410×10^{-10}, and 2052×10^{-10}, W being measured in joules per cubic centimetre per cycle. With $T = 20$ secs., and V_{max} having the values 34 volts and 68 volts respectively, the values of W were 266×10^{-10} and 1380×10^{-10}. E. C. R.

885. *Wave-forms in Three-phase Systems.* **A. Russell.** (Electrician, 48. pp. 487–489, Jan. 17, 1902.)—The author discusses the effect on three-phase circuits of a wave-form differing from the sine curve. In the case of a balanced star-connected circuit it is shown that, if f be the frequency of the currents in the outer conductors, a current will pass in the neutral wire, having a frequency $3(2n + 1)f$, where n is a positive integer. The lowest frequency for the current in the middle wire is therefore $3f$. It is shown that the load on a three-phase generator symmetrically loaded but giving non-sinusoidal current fluctuates with a frequency $6f$, and that the angular velocity and intensity of a rotating field produced by such currents likewise vary with this frequency. A. E. L.

886. *Measurement of Magnetic Hysteresis.* **G. F. C. Searle** and **T. G. Bedford.** (Roy. Soc., Phil. Trans. 198. pp. 33–104, Jan. 31, 1902. Roy. Soc., Proc. 68. pp. 348–352, July 9, 1901) (Abstract.)—The paper describes in detail the method employed to measure the energy spent in hysteresis, and gives the results of numerous measurements showing the relations between hysteresis loss and tension and torsion in iron and steel wires. The energy spent in a reversal of the magnetising current is measured by a ballistic dynamometer, the magnetising current passing through the fixed coils, while the induced current from a secondary winding passes through the suspended coil. The dynamometer was calibrated by an earth inductor. The theory of the method is developed very fully, and terms are introduced representing the losses of energy in eddy-currents and in the secondary circuit. These can be determined by observations with different resistances in circuit. As they depend on the rate of change of the magnetising current, the reversal of this must be effected gradually, for which reason a highly

inductive coil is included in the primary circuit, and a reversing key of special design is used, which introduces resistance before reversing.

Comparisons were made showing satisfactory agreement between the hysteresis loss as measured by the ballistic dynamometer and that calculated from the B-H curves obtained by a ballistic galvanometer. Simultaneous measurements of B and the hysteresis loss were made by using the ballistic galvanometer and the dynamometer.

In freshly annealed iron wire both B and the hysteresis loss were found to decrease with repeated reversals, the latter showing the greater change. Both are sensibly constant after some 40 cycles, and the change is less the stronger the field. The effect of tension is to increase B and the hysteresis to a maximum, and then to diminish them. Torsion causes both to decrease Curves are plotted between B and the hysteresis loss for constant field strength, the variations being due to torsion or tension; from these an equation is derived expressing the hysteresis loss in terms of B and H; it is of the form, $W = a . B\sqrt{H} + b$. The hysteresis loss was found to diminish when a current was passed through the wire; a current of 1·12 amperes in a wire 1 mm. in diameter decreased the hysteresis loss by 22·7 per cent. This is probably due to circular magnetisation by the current.

Two appendices are attached; the first treats mathematically of the heat produced by eddy-currents in rods of circular and rectangular sections; the second deals with the demagnetising force due to rods of finite length. As H was increased, the demagnetising force h increased to a maximum and then diminished to a minimum, and for high values of H was less than that which would obtain if the lines of induction issued only from the end surfaces. This small value of h implies the existence of poles between the centre and ends of the wire, due to non-uniformity in the wire caused by hysteresis. G. H. B.

887. *Distribution of Lines of Magnetic Induction.* **V. Karpen.** (Comptes Rendus, 134. pp. 88–90, Jan. 13, 1902.)—An approximate or arbitrary distribution of the lines of induction may be considered as a real distribution by supposing that the boundaries of the tubes of induction are impermeable to the lines of force. It may then be said that to each distribution there corresponds a certain intrinsic energy of the medium, and under these conditions the following principle may be enunciated: In a magnetic medium submitted to the action of a certain number of magnetomotive forces the course of the lines of induction is such that the intrinsic energy of the medium is a maximum. Let $\epsilon, \epsilon', \ldots$ be the magnetomotive forces acting, $\phi, \phi' \ldots$ the fluxes traversing these magnetomotive forces; then the intrinsic energy of the medium will be—

$$W = \frac{1}{8\pi}(K\epsilon\phi + K'\epsilon'\phi' + \ldots)$$

K, K′, ... being coefficients less than unity. The course of the lines of induction must be so chosen as to make this expression a maximum. If, as often happens, there is only one magnetomotive force, the flux traversing it must be a maximum, or, what comes to the same thing, the reluctance must be a minimum. J. J. S.

888. *Formulæ for Magnetisation Curves.* **E. Müllendorff.** (Elektrotechn. Zeitschr. 23. pp. 25–28, Jan. 9, 1902.)—On theoretical grounds the author

proposes the following two formulæ to represent the relation between magnetising force H and magnetic induction B—

$$B = ae^{-\frac{\beta}{H^{\mu}}} + H \text{ ....(1)}$$

and—

$$B = a\left\{1 - \frac{1}{(1 + bH^{m})^{n}}\right\} + H \text{ ....(2)}$$

The author discusses the means of determining the constants $a, \beta, \mu, b, m,$ and n from a suitable number of points on an experimental curve—a being strictly speaking the maximum value of B. To obtain more accurate results over a given length of curve, however, it is preferable to give a value found from that part—not necessarily corresponding to the extreme suturation. Both expressions give the concave part of the curve of initial magnetisation, being tangential to the axis of x at the origin, and having as asymptotes the saturation line a. Results are tabulated for curves given by Kapp for cast iron, wrought iron, mild steel, and armature sheet. The maximum differences between the observed values and those obtained by the two formulæ are as follows :—

	Cast Iron.	Wrought Iron.	Mild Steel.	Armature Sheet.
Formula (1)	7·3%	0·9%	1·5%	2·0%
Formula (2)	5·4%	1·5%	1·5%	2·0%

The difference in accuracy between the two formulæ is so small that Formula (1) is to be preferred on account of its greater simplicity. A. E. L.

889. *Behaviour of the Coherer in the Magnetic Field.* **E. Drago.** (N. Cimento, 2. pp. 319–321, Nov.–Dec., 1901.)—It has been shown by Opler (L'Elettricità, 1898, p. 29) that a tube containing iron filings, arranged axially between the poles of an electromagnet, acquires appreciable conductivity at the instant the magnetic field is created. The author describes similar experiments with an ordinary coherer containing powdered bismuth, the results of which show that the resistance of contact of such a coherer either remains unchanged under the action of the magnetic field, or else the changes are so small as to be masked by Righi's phenomenon. T. H. P.

890. *Magnetisation Constants of the Rare Earths.* **S. Meyer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 541–559, May and June, 1901. From the Physical Institute of the University of Vienna.)—The author gives his determinations of the magnetisation constants of the rare earths in a series of tables. If we arrange the metals in order of increasing atomic weight, we have the following values for the "molecular magnetism," K :—

	Y	La	Ce
K . 10⁶ =	(diamagnetic)	−0·23	+0·06.

	Pr	Nd	Sa	Gd	Ho	Er	Yb
K . 10⁶ =	3·3	5·2	11·2	27·3	50	38·2	6

The analogy with the iron group of the periodic table is unmistakable :—

	V	Cr	Mn	Fe	Co	Ni
K . 10⁶ =	1·3	6·3	15	12·5	10	5

D. H. J.

891. *Types of Terrestrial Magnetism.* **N. Umow.** (Soc. Imp. Nat. Moscou, Bull. 1. 2. pp. 1–72, 1902.)—The writer supposes a vector having arbitrarily assigned values at each point on a spherical surface. Taking for axis the diameter NS of the sphere, the components of that vector are X in the meridian, Y along a parallel of latitude, Z vertical. Consider the parallels of latitude u, u_1. At every point in the parallel u the resultant of X and Z may be produced till it cuts the plane of the parallel u_1. This being done for all values of u, the points of intersection of these resultants with the plane u_1 form an image on that plane of the vector distribution over the surface. If u be very near to u_1, then generally the image of the vectors on u is the circle u_1 itself. But an exception occurs when the resultant of X and Z for the circle u_1 lies in the plane of that circle. In that case the limiting position of the intersection with the u_1 plane of the resultant of X and Z for u, as u approaches u_1, may not be on the circle u_1. A parallel of latitude for which the resultants of X and Z are in the plane of the parallel is defined to be a *critical plane* of the type of vector distribution in question, and u_1 is the *critical angle.* An example is given, viz., a uniformly magnetised sphere. It is found that this distribution or type has two critical planes corresponding respectively to north and south latitudes $\cos^{-1}(\surd 3)^{-1}$. The above being the mathematical method, the writer considers a regular type of magnetisation which in its principal features resembles that of the earth, and supposes an image of the actual magnetisation to be formed on the critical planes of this regular type. Making use of Leyst's work "on the geographical distribution of normal and abnormal magnetism" (Moscow, 1899), he gives a table of the south to north components of magnetic force on Mercator's projection, and arrives at the conclusion that the best image of these is the image formed on the critical planes of the uniformly magnetised sphere, namely, latitudes $\pm\cos^{-1}(\surd 3)^{-1}$. In his second part the writer considers the possible magnetic types of an arbitrarily magnetised sphere, and shows that every distribution has a special or fundamental type and residual types. The mathematics of this part of the work cannot be given in an abstract. In the third part the investigation is applied to the special case of the earth on the foundation of Gauss' potentials, as calculated by Neumayer and Petersen. It is found that the fundamental type of the earth's magnetisation is that of a uniformly magnetised sphere. On this certain other types are superimposed, in particular one whose axis lies in the equatorial plane, here called the east-west distribution. S. H. B.

ELECTROPHYSIOLOGY.

892. *Independence of Closely Connected Functions of Muscle Fibre.* **T. W. Engelmann.** (Archives Néerlandaises, 6. pp. 689–694, 1901.)—The movement of a muscle depends on the simultaneous operation of three functional properties of its constituent elements, *i.e.*, excitability, conductibility, and contractibility. By the first of these is meant the faculty of such an element when excited of becoming active, which is indicated by the appearance of electric currents (action currents), and followed, after a short interval, during which the energy remains latent, by the mechanical process of contraction. Excitability is measured by the inverse ratio of the value of the most feeble excitation sufficing to produce a perceptible irritation, *i.e.*, the inverse of the threshold value (Schwellenwerth). Under normal circumstances this process of activity or of irritation is communicated by waves to neighbouring muscle constituents, even before contraction begins, and extends as far as there exists a physiological contact between such excitable muscle constituents or elements. The measure of conductibility is given by the velocity which characterises the process of inter-communication, while contractibility, finally, is measured by its mechanical equivalent. Notwithstanding the close connection between these functions referred to, however, they are, up to a certain point, independent of each other, and, under certain conditions, one of them may be entirely suspended while the others remain in full activity. The author describes as *bathmotropic* (from βάθμος = threshold) such influences as affect excitability, as *dromotropic* such as interfere with conductibility, and as *inotropic* such as lessen or destroy contractibility. The independence especially of conductibility is very striking, and has been known for a long time. Thus under certain circumstances, for instance, owing to the stoppage of circulation, conductibility may be reduced in the muscle fibres to zero, and yet a direct and primary act of an excitant may still provoke powerful "idiomuscular contractions." As a case in point it may be stated that water, as was discovered by W. Biedermann, may destroy entirely, or nearly so, the contractibility of an ordinary muscle (Sartorius) without producing any perceptible bathmotropic or dromotropic effect. The author who has experimentally studied especially bathmotropic influence, exercised both upon ordinary striated muscles, which are under the control of the will, and upon ventricles and auricles, and has already published some of the facts discovered by him, adds in this paper some new data. Thus he points out that when the commencement of a portion of the sartorius of a frog was inoculated with curare, after this portion had been dilated in water and deprived of its contractibility, without having lost either its excitability or conductibility, the threshold of excitation (Reizschwelle) was often not sensibly diminished.

Experiments made with reference to the heart showed similar results. In many such cases the velocity of transmission of the motive power in a portion of the sartorius or in the heart, which had been deprived of contractibility, was not diminished and occasionally was even increased, thus producing a positive dromotropic effect side by side with a negative inotropic effect. Nuel discovered that the action of the vagus not only diminishes the frequency of the cardiac contractions, but also the intensity of the systoles. Schiff and Eckhard, and, more recently, McWilliam and W. Mills, have demonstrated that excitation of the pneumogastric causes the ventricles and auricles to lose their direct excitability by means of electricity. The author's experiments have confirmed this fact in so far as they have shown that the heart, or at least its auricle, can be made to remain for a very short time passive to electrical or mechanical excitation by a strong excitation of the pneumogastric, but he maintains that the excitability of the auricle very soon returns to its normal condition—in fact, long before the diminution or total stoppage of its contractibility has ceased. The new facts discovered by the author confirm, in his opinion, his theory that the physiological process of irritation indicated by the so-called "action-currents," is linked to other constituents of the muscle than the mechanical process of contraction; otherwise their independence of each other would be incomprehensible. The question therefore arises whether the microscope may reveal to us the difference of these hypothetical constituents, or whether their difference lies beyond our limits of visual perception. The author has elsewhere (Archives Néerlandaises, (1), 27, 65, 1893), stated his reasons for assuming that the physiological effect indicated by the appearance of electric currents is linked to the birefringent portions of muscle fibre, while the mechanical effect of contractibility is linked to the monorefringent portions, and thinks that the result of his recent experiments strengthens his theory. G. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

893. *Decomposition of Acetylene during Combustion.* **F. Gaud.** (Comptes Rendus, 134. pp. 175–177, Jan. 20, 1902.)—The author finds that with a Manchester acetylene burner there is very little fouling during use with the usual gas pressure. When the passage of gas is very slow, however, fouling of the cup of the burner soon occurs, though the supply channels remain, even in this case, quite unobstructed. Bullier attributed the fouling to the formation and subsequent decomposition within the burner of polymers of acetylene. Now decomposition of acetylene occurs at temperatures of 100° and upwards. The author accordingly shows from measurements of the temperature of the gas just previous to its combustion, that this temperature rises above 100° when the passage of the gas is slow, but falls below 100° with a rapid current of gas. D. H. J.

894. *Pure Fused Lime.* **H. Moissan.** (Comptes Rendus, 134. pp. 136–142, Jan. 20, 1902.)—The author finds that pure lime does not fuse at the blowpipe with mixtures of acetylene and oxygen, or of carbonic oxide and oxygen, and, in the case of mixtures of hydrogen and oxygen, fusion only occurs when the gases are present in the proportion of 2 vols. of hydrogen to 1 of oxygen. Lime is much more readily fused in the electric furnace. After the fusion, part of the lime is obtained in crystals belonging to the regular system; these crystals appear to change on keeping to crystals belonging to a less symmetrical system. Non-crystalline lime has a specific gravity of 3·3, the regular crystals a specific gravity of 3·4; so that here, as in the case of magnesia, we have evidence of polymerisation. The heat of neutralisation is the same for the different varieties of lime. Fused lime was found to readily oxidise iron, manganese, nickel, cobalt, boron, silicon and titanium.

D. H. J.

895. *Polymorphism and Isomerism.* **R. Wegscheider.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 907–928, July, 1901. Aus dem chemischen Laboratorium der k.k. Universität in Wien.)—The author concludes that the distinction between polymorphism and isomerism is serviceable, though no sharp boundary between the two exists, and points out various things that serve to differentiate the one from the other. Thus, for example, isomerism is shown by differences occurring in the products of fusion, solution, or evaporation, or by differences in derived substances; it is in isomerism that the stable form in the neighbourhood of the melting-point has a lower melting-point than the labile form; it is in isomerism that the more stable solid under the given conditions has the greater solubility or the greater vapour pressure; and isomerism is probable if both solids form the same compound with very different reaction-velocities, or if in super-saturated solutions the super-saturation is removed with very different velocities.

W. E. T.

896. *Simultaneous Equilibrium of Homogeneous Systems.* **R. Wegscheider.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 561–618, May and June, 1901. Aus dem chemischen Laboratorium der k.k. Universität in Wien. Also Zeitschr

Phys. Chem. 39. pp. 257–308, Dec. 13, 1901.)—This paper deals with the chemical kinetics and statics of homogeneous systems, particularly in cases in which several reactions leading to equilibrium occur together. Exception is taken to Euler's theory of catalysis and the connection deduced by him between the equilibrium coefficients and the velocity constants (Ber. der Deutschen chem. Gesellsch., xxxiii. 3202, 1900), in that it involves the assumption that dissociation-equilibrium occurs instantaneously for an ester, water, acid, and alcohol. The author shows how in general the conditions of equilibrium may be derived from the laws of kinetics, taking as an example the reciprocal transmutation of three isomers, for which case the relation between the equilibrium coefficients and the velocity constants is derived, and it is shown that the pairs of reactions would be only in equilibrium, as well separately as together, if a determined relation existed between the velocity constants. It is shown that sometimes the conditions of equilibrium given by kinetics do not agree with those given by ordinary thermodynamics, the concentration ratios, according to thermodynamics, being independent of the total concentration, but according to kinetics, depending on it. The conditions under which this contradiction occurs are discussed, and it is suggested that it may be due to the equilibrium being then a stationary transmutation rather than equilibrium in the mechanical sense. The contradiction also disappears if one assumes in the thermodynamic derivation of the condition of equilibrium either that the variations occurring in the molecule numbers are not solely limited by stoichiometric conditions, or that the velocity constants in simultaneous reactions are not in general independent of one another. A similar contradiction also occurs in reference to catalysis. W. E. T.

897. *Simple Proof of Gibbs' Phase-rule.* **Kuenen.** (Roy. Soc. Edinburgh, Proc. 23. pp. 314–318, July, 1901.)—This proof, for which the author does not claim originality, depends on the assertion that for a system in equilibrium there must be an equation to be satisfied by the variables for every independent virtual reaction in the system. F. G. D.

898. *Change of Coefficient of Absorption of a Gas in a Liquid with Temperature.* **Kuenen.** (Roy. Soc. Edinburgh, Proc. 23. pp. 312–316, July, 1901.)—The solubility of a gas in a liquid is considered from the general point of view of the condensation of binary mixtures. The coefficient of absorption is defined as "the rate at which the mass of the gas is absorbed by unit mass of the liquid per unit partial pressure," where partial pressure = pressure of liquid mixture — vapour pressure of solvent. It is shown that a minimum must exist in the expression for the coefficient of absorption as a function of the temperature. For very soluble gases this minimum will probably occur at relatively high temperatures not far from the critical point, but for sparingly soluble gases it may occur at comparatively low temperatures, as found by Estreicher for the solubility of helium in water. F. G. D.

899. *Inorganic Ferments.* **D. McIntosh.** (Journ. Phys. Chem. 6. pp. 15–44, Jan., 1902.)—Colloidal silver or mercury, prepared by sparking the metal under water, decompose hydrogen peroxide in acid or neutral solutions, the metal gradually becoming dissolved, when the action ceases. The same effect is produced very rapidly in presence of alkalies, and is facilitated by rise of temperature, though not by light. T. M. L.

900. *Action of Silver Salts on Ammonium Persulphate Solution.* **H. Marshall.** (Roy. Soc. Edinburgh, Proc. 23. pp. 163–168, Jan., 1901.)—Solutions of potassium persulphate and silver nitrate, when mixed, yield a black precipitate of silver peroxide, which is probably formed by the hydrolysis of the silver persulphate produced. On replacing the potassium persulphate by the ammonium salt only slight precipitation of silver peroxide occurs, but the decomposition of the persulphate is shown by the formation of sulphate and free sulphuric acid. When ammonia is added to the mixed solutions of ammonium persulphate and silver salt there is no deposition of silver peroxide, which is used in the oxidation of the ammonia to nitrogen, large volumes of which are rapidly evolved. The action of the silver salt is a catalytic one, and a small quantity of it is capable of causing the interaction of large amounts of ammonium persulphate and ammonia, according to the equation: $3(NH_4)_2S_2O_8 + 8NH_3 = 6(NH_4)_2SO_4 + N_2$. In aqueous solution and in presence of silver salts ammonium persulphate slowly decomposes as follows: $8(NH_4)_2S_2O_8 + 6H_2O = 7(NH_4)_2SO_4 + 9H_2SO_4 + 2HNO_3$; for moderate concentrations the rate of decomposition is practically proportional to the amount of persulphate present. T. H. P.

901. *Solution of Metals.* 1. **T. Ericson-Aurén** and **W. Palmaer.** (Öfvers. Kongl. Vet. Aked. Stockholm, Förh. No. 7. 58. pp. 525–543, 1901.)—The authors endeavour to explain the solution of metals by investigating the simple case of the velocity of solution of zinc in dilute acids. Having shown that the law of mass action, as employed in the ordinary way, does not explain the experimental results, they maintain that they may easily be interpreted by assuming that the solution of metals is due to local galvanic currents, the slow solution of pure metals being a consequence of this theory. A special formula is deduced for the velocity of solution of zinc containing lead, the results of experiments agreeing most satisfactorily with the calculated ones. The authors then establish the following general formula for the velocity of solution ρ of a metal:—

$$\rho = f \cdot \frac{n}{c} \left\{ \frac{0{\cdot}0576}{n} \log \frac{P_1}{p_1} - 0{\cdot}0576 \log \frac{P_2}{p_2} - \pi \right\},$$

n being the valency of the metal, P_1 the pressure of solution, p_1 the osmotic pressure of the metal, P_1 and p_2 the same for hydrogen, π the excess of pressure due to metallic impurities, f a constant, n the conductivity of solution, and c the capacity of resistance of the system. This formula is discussed, and its possible application is pointed out. The theory of local currents accounts easily for the slightness of the effect of temperature on the phenomenon, and enables the catalytic effect of impurities to be calculated. Further experiments are in progress. A. G.

902. *Solubility of Potassium Hydroxide in Water.* **P. Ferchland.** (Zeitschr. Anorg. Chem. 30. 1. pp. 130–134, 1902.)—In spite of the practical importance of potassium hydroxide, both for pure and applied chemistry, most contradictory data are current as to its physical constants. The author maintains that the values given by treatises and tables for the solubility in water are all erroneous, and that the only reliable values for the density of potassium hydroxide are those obtained by extrapolation from Pickering's density measurements on solutions of caustic potash. With regard to the maximum concentration, the author points out that the necessity of a superior

limit of 61 per cent. is shown by the existence of the hydrate KOH, $2H_2O$, while it is a fact known to technical chemists that caustic potash of the density 1·58, as employed in the arts and manufactures, crystallises out readily on being exposed to winter temperatures, 50 per cent. being thus an inferior limit of solubility. He then proceeds to give an account of his own investigations on pure potassium hydroxide obtained by decomposing electrolytic potassium amalgam by a reversed current. After heating the 50 per cent. hydroxide solution in a closed silver vessel to the boiling-point (150°), and then cooling the vessel in cold water, the solution is placed in a thermostat, the hydrate above mentioned separating out in big crystals. Weighed quantities of the mother-liquor are next converted into potassium chloride, in order to analyse the solutions, the densities being ascertained by pycnometrical measurements.

The author deduces for the solution saturated at 15° the density 1·5355 (the unit being that of water at 4°), and a concentration of 51·7 per cent., in satisfactory agreement with the results obtained by extrapolation from Pickering's data. A. G.

903. *Nitriles as Solvents in Molecular Weight Determinations.* **L. Kahlenberg.** (Journ. Phys. Chem. 6. pp. 45–49, Jan., 1902.)—The molecular elevation of the boiling-point of benzonitrile as calculated from the latent heat of evaporation is 48·67, whilst Werner from the elevation of the boiling-point by diphenylamine obtained a value 36·5, assuming this substance to have its normal molecular weight. Taking the former value, evidence of polymerisation was obtained in solutions in benzonitrile of diphenylamine, mercuric chloride and iodide, and silver nitrate. The molecular elevation of the boiling-point of acetonitrile is calculated to be 14·5. Taking this value for the constant, molecular weight determinations gave slightly high values for naphthalene (143 for 128), and diphenyl (171 for 154), and low values for diphenylamine (125 for 169) and silver nitrate (135 for 170).

The low values for diphenylamine in acetonitrile correspond with those for silver nitrate, which gives an electrolytic solution, whilst diphenylamine is not an electrolyte. The high values for electrolytic solutions of mercuric chloride and iodide and silver nitrate in benzonitrile do not give any direct indication of electrolytic dissociation, but are in no way abnormal. T. M. L.

904. *Behaviour of Molecular Compounds in Solution.* **G. Bodländer** and **R. Fittig.** (Zeitschr. Phys. Chem. 39. pp. 597–612, Jan. 31, 1902.)—From solubility determinations and from the e.m.f. of concentration-cells the conclusion is drawn that a solution of silver chloride in ammonia contains the compound AgCl, $2NH_3$, and that this is dissociated in solution into the ions $\overset{+}{Ag}(NH_3)_2$ and $\overset{-}{Cl}$, and only to a very small extent into $\overset{+}{Ag}$, $\overset{-}{Cl}$, and $2NH_3$.
T. M. L.

905. *Determining Capillarity-Constants of Dilute Salt-Solutions.* **A. Gradenwitz.** (Inaugural Dissertation, Breslau, pp. 1–71, 1902. Abstract in Phys. Zeitschr. May 1, 1902.)—Mercury is contained in a U-tube with a wide and narrow limb arranged so that the mercury can be drawn out from the narrow limb to a constant level by means of a capillary point. The mercury in the wide limb is covered with water, and on adding small quantities of a stock salt-solution the change of surface tension causes a displacement of the mercury; this is compensated by addition or removal of a weighed quantity of mercury, and from the latter the surface tension is calculated. Values determined in this way are given for NaCl, KCl, LiCl, $NaNO_3$, KNO_3, LiNO. In all cases except LiCl the specific cohesion of the water is increased by the addition of the salt, and the increment can be expressed as the sum of a positive modulus for the kation and a negative modulus for the anion of the salt. T. M. L.

906. *Density of Dilute Solutions of Sulphates.* **C. M. Pasea.** (Elektrochem. Zeitschr. 8. pp. 215–221, Jan., 1902.)—McGregor has shown (Trans. Roy. Soc. Canada (1) 8. 19, 1890) that in dilute solutions of certain sulphates a given weight of solution occupies a smaller volume than would be occupied by the water it contains. Density determinations are given which show that sodium sulphate does not cause any such contraction, but that a contraction occurs in solutions containing less than 0·36g. $CdSO_4$, 0·28g. $MnSO_4$, or 0·5g. $FeSO_4$ per 100g. of solution; the contractions are always small, and in the case of manganese sulphate are hardly perceptible. T. M. L.

907. *Solubility of Calcium Carbonate in Aqueous Solutions of Certain Electrolytes in Equilibrium with Atmospheric Air.* **F. K. Cameron** and **A. Seidell.** (Journ. Phys. Chem. 6. pp. 50–56, Jan., 1902.)—In presence of atmospheric air calcium carbonate does not dissolve to any appreciable extent as such, but only as bicarbonate, except in sodium sulphate solutions when the solubility is relatively very great and the solution contains normal carbonate as well as neutral bicarbonate. The solubility in salt solutions exhibits a maximum at about 50g. NaCl per litre, and is much decreased if calcium sulphate is also present. T. M. L.

908. *Molecular Surface-energy of Solutions. Molecular Weight of Sulphur.* **D. Pekár.** (Zeitschr. Phys. Chem. 39. pp. 433–452, Jan. 17, 1902. Paper read before the Hungarian Academy of Science, March 18, 1901.)—The method introduced by Eötvös for determining the complexity of liquids from their surface tension can be extended to liquid mixtures, as was found from measurements of ether with carbon disulphide, with benzene, and with diphenylamine (compare Ramsey and Aston, Proc. Roy. Soc., 1894, 56. 182). On applying this method to solutions of sulphur in CS_2 and S_2Cl_2 evidence was obtained that the sulphur molecule is probably octatomic in both solvents. The paper contains a detailed description of the method used by Eötvös for the determination of surface tension. The critical temperature of S_2Cl_2 was calculated from the surface tension to be 395°. T. M. L.

909. *Clarification of Turbid Solutions.* **G. Quincke.** (Ann. d. Physik, 7. 1. pp. 57–96, Dec., 1901.)—The clarification of turbid solutions can be brought about by non-electrolytes as well as by electrolytes; liquids like chloroform act in this way, forming an oily layer on the surface of the particles, which gradually collect into a flocculent precipitate. This is sometimes formed on the light and sometimes on the dark side of the vessel. The silvering of glass by the chemical method is regarded as a special case of the clarification of a turbid solution, the particles separating where the vessel is illuminated. T. M. L.

910. *Liquid Sulphur Dioxide as a Solvent.* **P. Walden** and **M. Centnerszwer.** (Zeitschr. Phys. Chem. 39. pp. 513–596, Jan. 31, 1902. Abstract from the Acad. Sci. St. Pétersbourg, Bull., No. 1, June 15, 1901.)—The purest sulphur dioxide has a specific conductivity $l = 0{\cdot}9 \times 10^{-7}$ in reciprocal Siemens ohms per centimetre cube at 0°, a value intermediate between that of water, $0{\cdot}4 \times 10^{-7}$ at 18°, and that of liquid ammonia, $1{\cdot}33 \times 10^{-7}$ at $-79{\cdot}8°$. Measurements are given of the conductivity at 0° of solutions in sulphur dioxide of nineteen salts, all of them being chlorides, bromides, iodides, or sulphocyanides; in many cases the conductivity was found to be greater than in aqueous solution at 0°. Ostwald's Law of Dilution is not applicable to solutions in sulphur dioxide, nor do the modified laws proposed by Rudolphi and van't Hoff serve to express the relationship between conductivity and dilution. In aqueous solutions the equivalent conductivity often approaches its limiting value when dilutions of about 1,000 litres per equivalent are reached, but the equivalent conductivity of solutions in sulphur dioxide is still far from its limiting value at a dilution of 2,000 litres, and it is not yet possible to determine the magnitude of the equivalent conductivity at infinite dilution. For this reason it is not possible to determine with any degree of accuracy whether Kohlrausch's law of the independent migration of the ions is applicable to these solutions. In the case of aqueous solutions the temperature coefficient of conductivity is always positive at ordinary temperatures, and usually amounts to about 2 per cent. per degree Centigrade, but Arrhenius has shown that in some cases maxima of conductivity occur at higher temperatures, the temperature coefficient becoming zero and then negative. In the case of solutions in sulphur dioxide at 0° C., the temperature coefficient is irregular and usually negative, but a maximum of conductivity is reached at a lower temperature, and the temperature coefficient then becomes positive; the conductivity-temperature curves are therefore of the type first observed by Arrhenius in the case of phosphoric and hypophosphorous acids; the temperature of maximum conductivity is highest for the solutions of highest conductivity, and in some cases is above 0°, the temperature coefficient at 0° being then positive. At the critical temperature the solutions cease to conduct. Quinoline, pyridine, α-picoline, and triphenylphosphine give conducting solutions in sulphur dioxide, although the method of ionisation is by no means obvious. Molecular weight determinations by the boiling-point method lead to perfectly normal results for solutions of non-electrolytes in sulphur dioxide; the molecular elevation of the boiling-point is $E = 15{\cdot}0$. Electrolytic solutions give results of an entirely different character to those obtained with aqueous electrolytes; evidence of electrolytic dissociation was only obtained in the case of two iodides, and even here the *i*-factor, which measures the "degree of dissociation," decreases towards unity with increasing dilution. The majority of electrolytes appear to be strongly associated in strong solution, but all tend towards a monomolecular state in dilute solution. Sulphur dioxide has only a moderately large dielectric constant (18·75), and, contrary to the rule of Dutoit and Aston that electrolytic solvents are highly associated, is shown by its surface tension and latent heat of evaporation to be monomolecular. T. M. L.

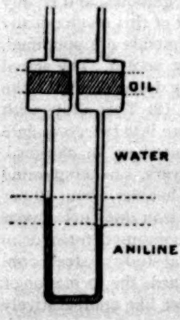
911. *Solubility of Dicalciumphosphate in Water.* **A. Rindell.** (Comptes Rendus, 134. pp. 112–114, Jan. 13, 1902.)—The results of a number of measurements of the solubility of dicalcium phosphate in water show that: (1) The concentration of the solution increases with the time and with the amount of the salt in contact with a given volume of water. (2) The ratio H_3PO_4 : CaO is at first 1·13 and increases with the concentration to the value 1·56. Electrical conductivity determinations confirm the author's previous statements that this salt dissolves with decomposition at the ordinary temperature, and that some times elapses before a state of equilibrium is attained. If the proportion of the phosphate employed is less than 10 grm. per litre of water, the solution becomes saturated after 252 hours. As the saturation becomes more nearly complete, the ratio H_3PO_4 : CaO of the solution increases. T. H. P.

912. *Alloys of Copper and Iron.* **J. E. Stead.** (Metallographist, 5. pp. 25–41, Jan., 1902.)—After referring to the experiments of previous investigators, the author proceeds to give the results of his own investigations, and arrives at the following conclusions: (1) That carbon when present limits the amount of copper which can be alloyed with iron, the maximum of 7·5 per cent. being the limit in gray hæmatite iron containing 3 per cent. silicon, and about 15 per cent. in steel with 1 per cent. carbon; but in most of the carbon-iron-copper alloys some of the copper exists as globules, and is only mechanically suspended in the solid metal. The amount of this mechanically suspended copper varies with the rates at which the metals are solidified, being highest when rapidly, and lowest when very slowly, cooled. The actual amount retained in solution when solid has not been fully determined. In the steel the amount does not probably exceed 7 per cent. (2) That alloys with about equal parts of copper and iron, which do not separate into two conjugate liquid layers before solidification, when remelted at a white heat on charcoal, absorb carbon, and then separate into two liquid layers, one containing about 2 per cent. carbon and 10 per cent. copper, the heavier about 10 per cent. iron and 0·08 per cent. carbon. (3) Copper in cast iron does not appear to have any influence in retaining the carbon in the combined form, or in causing a separation of graphite. (4) The micrographical study of steels containing copper leads to the conclusion that the copper retards the formation of pearlite. The same steels, differing only in copper, under like comparatively rapid cooling, when cold contain more diffused carbide when copper is present than when absent. On very slow cooling, the carbides appear to separate equally in both the cupreous and normal steels. This peculiarity explains why annealing and slow cooling have the marked softening effect referred to by Lipin and others on cupreous steels. (5) That copper in foundry iron need not be feared, as its only effect appears to be that of raising its tenacity. (6) That the somewhat conflicting statements of the authorities in our text-books appear to have been due to the fact that some of them may not have taken into consideration the effect of carbon in preventing copper alloying with iron. Pig iron will only alloy with small quantities of copper, whereas pure iron will alloy with any proportion. The article is illustrated with micro-photographs, showing the effect of etching, polishing, and heating upon different alloys. O. J. S.

913. *Thermo-chemistry of Alloys of Zinc and Aluminium.* **W. Louguinine** and **A. Schukareff.** (Archives des Sciences, 13. pp. 5–29, Jan., 1902.)—The heats of formation of the alloys were determined in a Berthelot calorimeter from the heats of solution of the alloys and of the constituent metals in dilute hydrochloric acid. The results in calories for one grm. of alloy were:— Al_5Zn, − 131·7; Al_4Zn, − 5·0; Al_3Zn, + 1·4; Al_2Zn, + 23·4; AlZn, + 9·1; Al_2Zn_3, + 2·3; $AlZn_2$, − 4·0; $AlZn_3$, + 15·2; so that only doubtfully in the first case, have we any evidence of the existence of a definite alloy. Heycock and Neville came to the same conclusion from an examination of the melting-points of zinc-aluminium alloys. D. H. J.

914. *Properties of Colloids.* **P. D. Zacharias.** (Zeitschr. Phys. Chem. 39. pp. 468–484, Jan. 17, 1902.)—The paper is non-experimental, and deals with the properties of colloids in general, from the point of view that the molecules of colloids may be regarded as inelastic flexible membranes, and that colloids are honeycomb masses of such membranes. D. H. J.

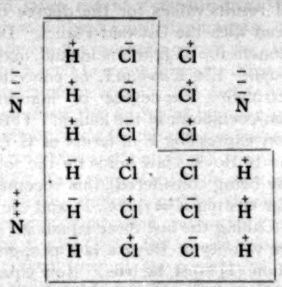
915. *Influence of Concentration on the Ionisation Factor of Moderately Dilute Aqueous Solutions.* **A. Smits.** (Zeitschr. Phys. Chem. 39. pp. 385–432, Jan. 17, 1902.)—A very sensitive micromonometer was obtained by utilising the small difference in density between aniline (1·028) and water (0·999) as shown in the Figure. The water was rendered feebly alkaline by boiling with soda-glass, to prevent the aniline sticking to the sides of the tube. The sensitiveness depends on the relative widths of the narrow tube containing the water-aniline meniscus and the wide tube containing the water-oil meniscus, and in the apparatus used was found by two independent methods to be in the ratio of 1 : 0·03285 as compared with a water-manometer. With the micromanometer, direct determinations of the lowering of the vapour pressure were made with aqueous solutions of salt, potassium nitrate, sulphuric acid, and cane sugar. The molecular lowering of the vapour pressure was found to increase slightly with increasing concentration in the case of cane sugar, but to decrease from an initial high value ($i = 1{\cdot}84$) in the case of potassium nitrate; in the case of salt and of sulphuric acid the molecular lowering at first decreases, then reaches a minimum at about 0·5 mols. per 1,000g. H_2O, and increases again; this minimum is not easily accounted for, but has been observed independently by Dieterici, and is in accord with observations by Loomis and Ponsot on the freezing-points of very dilute solutions. Two new forms of apparatus were devised for determining accurately the elevation of the boiling-point; NaCl and KCl gave a minimum elevation of the boiling-point at 0·3 mols. per 1,000g. H_2O, but KNO_3 gave a steadily increasing value; $Sr(NO_3)_2$ gave a minimum value, but not $NaNO_3$, $Ba(NO_3)_2$, $AgNO_3$, and $Pb(NO_3)_2$. T. M. L.



916. *Reaction between Chlorine and Ammonia.* **W. A. Noyes** and **A. C. Lyon.** (Chem. News, 85. pp. 14–15, Jan. 10, 1902.)—If dilute ammonia solution (0·5 per cent.) be allowed to act on chlorine gas, as in Hofmann's well-known lecture experiment, it is found that if excess of ammonia be avoided, so that the solution is left faintly acid, the volume of residual nitrogen approaches very closely to *one-sixth* of the chlorine. A quantitative investigation of this reaction shows that it can be expressed as follows :—

$$3NH_3 + 6Cl_2 = N_2 + NCl_3 + 9HCl$$
$$9HCl + 9NH_3 = 9NH_4Cl.$$

The nitrogen chloride was estimated by shaking out with benzene and titrating with alkaline arsenite solution. If excess of ammonia be used, the nitrogen chloride reacts with it, giving nitrogen and probably also ammonium hypochlorite, whereas if insufficient ammonia be used, the ammonium chloride formed in the reaction acts on the chlorine, forming nitrogen chloride. The author's main contention is that if the reaction be conducted as described above, then six molecules of chlorine must react *simultaneously* with three molecules of ammonia, for if the production of nitrogen chloride were due to a secondary reaction it would be difficult to explain the simple quantitative relations observable. On this groundwork the authors develope the hypothesis that all reactions involving decomposition of molecules are preceded by "ionisation," and that elementary molecules may ionise into positive and negative parts. Thus the present reaction may be formulated as follows :—


$\overset{+}{H}$ $\overset{-}{Cl}$ $\overset{+}{Cl}$
$\overset{\equiv}{N}$ $\overset{+}{H}$ $\overset{-}{Cl}$ $\overset{+}{Cl}$ $\overset{\equiv}{N}$
$\overset{+}{H}$ $\overset{-}{Cl}$ $\overset{+}{Cl}$
$\overset{-}{H}$ $\overset{+}{Cl}$ $\overset{-}{Cl}$ $\overset{+}{H}$
$\overset{+++}{N}$ $\overset{-}{H}$ $\overset{+}{Cl}$ $\overset{-}{Cl}$ $\overset{+}{H}$
$\overset{-}{H}$ $\overset{+}{Cl}$ $\overset{-}{Cl}$ $\overset{+}{H}$

This explanation involves the further idea that in the ionisation of ammonia, the hydrogen may become either positive or negative. This view is not so improbable as it seems at first sight when one recollects that the hydrogen of ammonia may be replaced either by chlorine or sodium.

F. G. D.

917. *Internal Resistance of Galvanic Cells.* **C. H. Ayres, Jr.** (Phys. Rev. 14. pp. 17–37, Jan., 1902.)—This investigation was undertaken to determine experimentally whether the internal resistance of a cell is a function of the current. The method adopted was a modification of that due to Kohlrausch, one of the resistance arms of the bridge being made up of a fixed capacity in series with a variable resistance, and the other arm of a fixed capacity in series with the cell. The remaining arms consist of a slide wire. If a, b are the sections of the wire, then for equilibrium we have $r_1/r_2 = a/b = c_2/c_1$. The method of operation is to move the slider until a minimum is found, then vary r_2 (r_1 being supposed fixed) so as to improve the minimum ; then move the slider again, and so on. The value of r_2 was found by measurement on a separate Wheatstone bridge. The cell is either on open circuit or shunted with a known resistance as desired. Any capacity effect due to polarisation unites itself with the capacity already in circuit, and thus an error of that kind is avoided. This method determines both capacity and resistance, but the figures given only refer to the latter. Both paper and mica condensers were used, the latter having a capacity of 30 mf. Measurements on known resistances showed that the method was accurate to $\frac{1}{25}$th per cent. Upon testing Daniell, Leclanché and Dry cells the author found the resistance was independent of the current.

The experimental part of the paper is followed by a theoretical part which shows how the accuracy depends upon the inductance, capacity, and resistance, and upon the frequency of the current. W. R. C.

918. *Tests of Dry Cells.* **C. F. Burgess.** (Elect. World and Engineer, 39. pp. 156–157, Jan. 25, 1902.)—The author gives tests by A. A. Radtke on a

number of dry cells [names not given]. The cells were submitted to both steady and intermittent tests, the results varying considerably. A rise in temperature of 70° C. increased the e.m.f. only about 0·1 volt. W. R. C.

919. *Jahn's Measurements of the E.M.F. of Concentration Cells.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 37. pp. 308–314, May 31, 1901.)—Employing Nernst's formula for the e.m.f. of a concentration cell, Jahn calculated from his experimental results values for the degree of ionisation of strong electrolytes which agreed with the Ostwald-Planck "Dilution-law." According to the author this conclusion of Jahn's is invalid, inasmuch as the argument involves a *petitio principii.* Let $E =$ e.m.f. of concentration cell; $C =$ total concentration of electrolyte; $r =$ degree of ionisation; $i =$ van't Hoff's factor; $x =$ transvection-coefficient of the kation. Thermodynamical reasoning leads to an equation expressing E in terms of C, i, and x, which may be written $E = f_0(C, i, x)$. If Boyle's law holds for the solution, *i.e.*, if $r = i - 1$ (binary electrolytes only being considered), this becomes $E = f_1(C, r, x)$, while Nernst's formula may be written $E = f_2(rC, x)$, and the Ostwald-Planck Mass Action law $r = f_3(C)$. Calling the last three equations (1), (2), and (3) respectively, and granting the validity of Boyle's law as applied to the dilute solutions concerned, equation (1) must be true. Now equation (2) follows from (1) only if (3) be true, as was first shown by Krüger [see Abstract No. 1550 (1901)]. Hence if (3) does not hold, neither will (2). Yet a series of *fictitious* values of r calculated on the *assumption* that (3) did hold good would satisfy (2), and conversely. This is the error made by Jahn according to the author. The latter accordingly recalculates Jahn's results (for KCl and NaCl), employing the equation (1). The values of r so obtained are, however, uniformly higher than those calculated from the conductivities. This unexpected result is discussed by the author, and various possibilities considered, the final result being that the whole question must for the time being be left undecided. [See also Abstract No. 1145 (1901).] F. G. D.

920. *Gas Cell Measurements.* **V. Czepinski.** (Zeitschr. Anorg. Chem. 30. 1. pp. 1–18, 1902.)—The author finds for the e.m.f. of the hydrogen-oxygen cell values as high as those derived from Bose's extensive researches. He next goes on to record his investigations on concentration cells, drawing the following conclusions from the results of experiments: Methyl hydride is a gas electrically entirely indifferent, being able to affect the potential of other gases possessing electromotive activity only by diluting them. Hydrogen partial pressure electrodes will very quickly reach a state of equilibrium. The smaller the partial pressure of the hydrogen surrounding the electrode the more slowly is this equilibrium arrived at. Diminution of kinetic energy and corresponding increase of potential energy are mainly a consequence of the depolarising effect of oxygen and of diffusion phenomena. The slightest traces of oxygen will exhibit a noticeable influence, the more so the more dilute the gas exposed to the effect of oxygen. A. G.

921. *Secondary Reactions in Electrolysis.* **J. W. Richards.** (Frank. Inst., Journ. 152. pp. 201–222; Discussion, pp. 222–224, Sept., 1901.)—The author considers secondary reactions, which he defines as those reactions whereby substances other than ions come into existence at the electrodes. The energy rendered latent by electrolysis includes the energy necessary for secondary as well as primary reactions, and the former generally assists the current. After considering the effect of temperature the author gives a classification of secondary reactions, and examples showing the effect of secondary reactions upon the voltage necessary for electrolytic decomposition. W. R. C.

922. *Influence of Diaphragms on the Transport-Numbers of the Ions.* **W. Hittorf.** (Archives Néerlandaises, 6. pp. 671–688, 1901.)—Many determinations of transport-numbers made forty years ago with the help of diaphragms differ substantially from more recent determinations by Jahn [see Abstract No. 1967 (1901)] and others without using diaphragms. The diaphragms were introduced in order to prevent the wandering from the cadmium anode of traces of cadmium solution which tend to move upwards through the liquid instead of sinking down to the bottom of the vessel. The earlier conclusion that a porcelain diaphragm does not affect the transport-number is now confirmed, and silk gauze can also be suitably used for the same purpose. But it is now shown that when an animal membrane is employed abnormal values frequently occur; in the case of KCl, NaCl, and NH_4Cl the only effect of the membrane is that a small amount of the solution is carried through it with the current, but without any change of concentration and without affecting the transport-number; in the case of $MgCl_2$, $CaCl_2$, $BaCl_2$, and especially $CdCl_2$, the effect of the passage of the current through the membrane is to cause the solution to pass through it *in the opposite direction,* and at the same time the liquid passing through the membrane is concentrated, in one case at least, to six times the strength of the bulk of the solution; in such cases when an animal membrane is used as a boundary for determining the migration of the ions the values obtained for the transport-numbers are altogether incorrect. By means of a device of Töpler (Pogg. Ann. 127. 556), these phenomena can be rendered visible to the eye, and, with a current passing upwards through a horizontal membrane, streaks of heavy liquid are seen falling down from the membrane, whilst the exhausted liquid from the upper side of the membrane rises to the surface, in the case of cadmium chloride and other salts of the group; in those cases where the membrane does not affect the transport-numbers no such streaks are seen. By this optical method LiCl and the iodides, nitrates, and acetates of the alkalies are shown to behave normally, whilst $TlNO_3$, $AgNO_3$, HCl, HNO_3, and even $CuSO_4$ (which gives practically a normal transport-number) are classed with $CdCl_2$. T. M. L.

923. *Potential Difference in Gas Flames and Solid Electrolytes.* **R. v. Hasslinger.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 696–705, May and June, 1901. From the Privat laboratorium des Verfassers in Prag-Smichov.)—The author investigates the potential difference that arises between two metal leaves suspended in a flame containing various solid electrolytes. The results are different from those for aqueous solutions or for ionised air. The leaves suspended in the flame are capable of being moved to different parts, and it is found that only in the symmetrical position do leaves, even of the same metal, show no potential difference. The leaves are connected by a reversing key to a Kelvin electrometer. A Teclu burner was used, and into it the solution of the salt to be investigated was sprayed. Both the sprayer and the burner were regulated by manometers. Results are given for leaves of iron, nickel, and platinum and for a variety of salts. The effect of variation of temperature for an iron platinum pair of leaves is also investigated, the electrolytes in this case being in a molten condition. The temperature is measured by a platinum palladium thermo element. Iron and platinum leaves in melted lithium chloride give volts 0·68, 1·07, 0·88, 0·77 for

temperatures 850°, 800°, 1,000°, 1,100° respectively. This turning-point in the e.m.f. for rising temperatures led to the idea that at higher temperatures the e.m.f. would pass through zero, and then change sign. This being investigated for magnesium oxide and calcium oxide, proved correct, and an illustrative curve for the latter is given, showing the zero point at nearly 1,000°. The lithium chloride vapour of the first experiments was then investigated for the same effect. For the high range (1,000° to 1,500°) the flame was employed, and for the lower temperatures (500°–800°) the salt was vaporised in a platinum tube. A similar reversal of e.m.f. was found.

J. W. P.

924. *Theory of Electrolytic Preparation of Copper.* **F. Egli.** (Zeitschr. Anorg. Chem. 30. 1. pp. 18–86, 1902.)—The author gives first a very full account of previous endeavours to prepare copper by an electrolytic process. From his own extensive researches on the matter the following are the main conclusions arrived at: Cu_2S being the anode in a sulphuric acid solution, copper will dissolve as copper ion, while the sulphur precipitated will give rise to passage resistances. With respect to Bernfeld's results, that with high current densities oxidation will take place, the author points out that this was not observed at densities in commercial use. Cu_2S being the anode in a hydrochloric acid solution, copper will partly dissolve as copper ion, though there may be an excess of chlorine separated. The dependence of the ratio of cuprous- and cupric-ions on density of current and acid has not yet been determined, but the author finds that under certain definite conditions cuprous chloride is formed. Sulphur will be oxidised to H_2SO_4 by nascent Cl. Cu_2S being the anode in an alkaline solution, Bernfeld's researches have shown that the metal will be converted into its hydroxide, the sulphur passing through all degrees of oxidation to sulphuric acid. Cu_2S being the kathode in an acid solution, according to Bernfeld's results, sulphuretted hydrogen will be produced at the kathode, the metal remaining at the electrode, while in an alkaline solution sulphur will dissolve as ion, the metal forming a muddy mass. The author confirms these results. After these preliminary studies, the author more particularly tests the precipitation of copper from cupric chloride solutions. As rapid circulation of the electrolyte greatly diminishes the amount obtained, it should be only just sufficient to maintain uniformity in the electrolyte. The presence of hydrochloric acid, while assuring a greater purity of copper, will considerably diminish the efficiency of the process. The addition of NaCl is favourable to purity, as it tends to prevent the formation of cuprous chloride, with only a slightly decreased efficiency. A large percentage of cupric chloride is unfavourable either to efficiency or purity, as it increases the formation of cuprous chloride; but the percentage should not be less than about 0·05 molecule per litre, as the metal would then separate in a spongy state. Raising the temperature enables the current density to be increased, giving higher efficiency, the solubility of copper in the electrolyte not being sensibly affected thereby, as long as Faraday's law is satisfied. From an electrolyte of the composition: 0·1 molecule $CuCl_2$, 0·1 molecule HCl and 0·4 molecule NaCl, a precipitate containing 99·90–99·98 per cent. of copper has been obtained.

A. G.

925. *Precipitation of Colloids by Electrolysis.* **W. R. Whitney** and **J. E. Ober.** (Zeitschr. Phys. Chem. 39. pp. 630–634, Jan. 31, 1902.)—Starting from the work of Linder and Picton on the precipitation of colloidal

solutions of arsenious sulphide by solutions of barium chloride, the authors find that the precipitated sulphide of arsenic contains a definite percentage of barium in the case of dilute solutions of precipitant and sulphide solution; this percentage is independent of the amount of barium chloride used as precipitant or its concentration. When solutions of calcium chloride, strontium chloride, or potassium chloride are used in place of the barium chloride, similar results are obtained. Moreover, the amounts of calcium, strontium, or potassium in the precipitated sulphide are chemically equivalent. D. H. J.

926. *Polarisation-Capacity and Dissipation of Energy of Voltameters carrying Alternating Currents.* **A. Franchetti.** (N. Cimento, 2. pp. 312–318, Nov.–Dec. 1901.)—The author gives the results of measurements of these magnitudes, made by the three ampere-meter method, for voltameters with (1) electrodes of lead or iron with sodium carbonate solution as electrolyte; and (2) electrodes of nickel, the electrolyte being a solution of sodium carbonate, or nickel sulphate or potassium or sodium hydroxide. The voltameters with lead electrodes and containing saturated sodium carbonate solution exhibit at temperatures of 10–15° a minimum of capacity for a certain value of the effective potential difference applied to the poles, this varying, according to the formation of the voltameter, from 0·89 to 1·07 volts. Under such conditions, and considering the voltameter as constituting two condensers in cascade, the capacity per sq. cm. of electrode varies from 580 to 290 microfarads, and the lead of the current with reference to the potential difference at the poles from 48° to 58°, whilst the increase of the resistance (energy dissipated divided by the square of the current intensity) over the resistance of the electrolyte attains finally to three times the value of the latter. With iron electrodes, however, the resistance of the voltameter is but slightly greater than that of the electrolyte, and is almost independent of the intensity of the current; the capacity varies from 980 to 2,200 microfarads per sq. cm. Voltameters with nickel electrodes, and electrolytes of alkaline carbonates or hydroxides, show similar behaviour. For nickel electrodes and an electrolyte of potassium hydroxide curves are given of the variable quantities for different frequencies. It is found that the impedance increases only to a very slight extent with the frequency, and that the mean capacity during a period is inversely proportional to the frequency. The increase of resistance of a voltameter over that of its electrolyte has been attributed by Wien to spontaneous depolarisation, but, in the light of his present results, the author considers the greater dissipation of energy as due partly to an increase of resistance and partly to polarisation loss. T. H. P.

927. *Electric-resistance Magnesia Crucible-furnace for Laboratory Use.* **H. M. Howe.** (West. Electn. 30. p. 28, Jan. 11, 1902. Paper read before the American Institute of Mining Engineers at its Mexican meeting in Nov., 1901.)—This furnace is employed by the author for the determination of the cooling curves of steel and the determination of melting-points. It was originally designed by him for use in calibrating thermo-electric couples by means of the melting-point of copper. The furnace itself consists of two semi-cylinders of magnesia, with a cover and cone-shaped stopper of the same material, the stopper being perforated to admit the leads of a thermo-electric couple. The interior of the furnace is designed with a spiral groove, fitted with a coil of platinum wire, through which a current of any desired strength is passed, and by means of which the crucible is heated. In the

author's opinion the unsuccessful attempts with furnaces of this class may be attributed to the use of siliceous materials for the furnace walls, the silica, upon electrolysis, decomposing, and the resultant silicon alloying with the platinum. The employment of magnesium, however, overcomes this difficulty. A detailed sketch of the furnace is given. O. J. S.

928. *Current Efficiencies Obtained in the Electrolytic Production of Alkaline Hypochlorites and Chlorates.* **F. Foerster** and **E. Müller.** (Zeitschr. Elektrochem. 8. pp. 8–17, Jan. 2, 1902. From the Elektrochem. Laboratorium, d. Köngl. Hochschule at Dresden.)—These investigations are a continuation of the previous work by Foerster [see Abstract No. 1946 (1899)]. The authors state that they have obtained practically theoretical yields in the case of chlorate production, and have also defined the yields in the case of hypochlorites. The chief causes of bad yields are kathodic reduction of the hypochlorites, and the evolution of gaseous oxygen, as already pointed out by former investigators. Chromates added to the electrolyte prevent this kathodic reduction, as found by Imhoff, and also E. Müller, inasmuch as they form a diaphragm round the kathode, and also prevent the disintegration of the latter, no matter whether they consist of metal or carbon. (1) Reduction of evolution of oxygen in the production of hypochlorites. The employment of chromates admits of the use of much greater concentration, and thus ensures a higher yield. The following table shows the results so far obtained by various investigators :—

Investigator.	Temperature.	Current Density at Anode.	Grs. per Litre.	E.M.F.	Yields.		Current Efficiency.
					Grs. of Hypochlorite per litre.	Grs. of Available Chlorine per litre.	
Brochet ...	15·5	0·045	200grm. KCl	4·2	5·4	23·5	84·0
E. Müller	8–12	0·075	300grm. NaCl	5·4	4·36	19·3	92·0
E. Müller	8–12	0·075	300grm. NaCl	5·4	5·88	26·0	80·0
Foerster ...	18	0·17	280grm. NaCl	5·0	6·8	30·1	82·0
Haber und Grinberg...	20–24	1·0	200grm. KCl	...	5·16	22·84	32·4
Haber und Grinberg...	18–30	2·0	200grm. KCl	...	3·15	13·96	80·0

From this table it may be seen that in order to obtain high hypochlorite concentrations high current density had to be used ; on the other hand, by the use of chromates there is no limitation in this direction. Solutions of alkaline chlorides, to which chromates have been added, and electrolysed at low temperatures between electrodes covered with platinum black, are the best conditions under which hypochlorites can be produced. Tabulated results, showing a current efficiency in the neighbourhood of 95 per cent., illustrate this contention. 1 grm. of hypochlorite-oxygen required from 8·8 to 16·6 watt-hours. Solutions containing as much as 38·5 grm. available chlorine per litre were obtained. The best technical results hitherto obtained in the production of hypochlorites were 13 grm. of chlorine per litre with an expenditure of 25·5 to 40·9 watt-hours per grm. of hypochlorite-oxygen, thus showing what a great progress the authors have made in this direction. The chromates contained in the authors' solutions can be easily removed by careful neutralisation with barium chloride. The covering of the electrodes with platinum black is done electrolytically from solutions of platinum hydrogen chloride and lead acetate. (2) Reduction of evolution of anodic oxygen in the case of chlorate production. The authors state that in submitting neutral alkaline chlorides to electrolysis it is possible to obtain a 90 per cent. current efficiency with the use of smooth platinum anodes if, before the maximum concentration of hypochlorite is obtained, the solution is partly or exactly neutralised by acid. Particulars of experiments on these lines, as well as tables, are given. Practically theoretical yields were obtained when using anodes covered with platinum black, chromates as depolarisers, and with the judicious use of hydrochloric acid. O. J. S.

929. *Darling's Method of Electrolytic Decomposition of Fused Nitrates.* (Frank. Inst., Journ. 153. pp. 61–68, Jan., 1902.)—A committee appointed by the Institute to investigate the Darling process for obtaining metals and nitric acid from fused nitrates have reported as follows: The process is protected by American patents—517001 of 1894, 590826 of 1897, and 641276 and 641438 of 1900. The last-named patent is the most important, and describes a device for using the current to protect the diaphragm from the action of the sodium, which is otherwise liberated at its surface. The experimental plant, which was witnessed in operation, worked satisfactorily, but the power required to work it is high, owing to the resistance offered by the diaphragms. The process is, however, likely to be of value where cheap power is available. A material suitable for use in fused nitrates as diaphragm has been discovered, and the difficulties attendant upon the practical use of such diaphragms have been overcome by an ingenious device. A John Scott Premium and Medal have been awarded to the inventor. J. B. C. K.

930. *Corbin Process and Cell for the Electrolytic Production of Chlorates.* **J. B. C. Kershaw.** (Elect. Rev. 50. pp. 83–84. Jan. 17, 1902.)—This article deals with the commercial development of the above process, which is carried on at the works of Messrs. Corbin & Co., at Chedde, in Savoy, where it has been in operation since 1896. The current efficiencies of the various electrolytic cells for chlorate production have varied in the early days of the manufacture between 35 and 52 per cent., but recent laboratory investigations have proved that much higher efficiencies than these can be obtained if the reducing action of the hydrogen liberated at the kathode be suppressed. The addition of alkaline carbonates, calcium chloride, and potassium chromate to the electrolyte have been recommended for this purpose, and although exact information is not available, it is probable that one or other of these additions to the electrolyte is now adopted at the Chedde Electrolyte Chlorate Works, for in a recent letter to the author P. Corbin states that a current efficiency of 85 per cent. is attained in the process, and that it is hoped ultimately to attain one of 90 per cent. The consumption of chlorates since 1899 has rapidly grown, and the chlorate and perchlorates produced at Chedde are largely used in the manufacture of a new explosive called "Cheddite." A description of the plant is given, besides sketches showing construction of cell. [See also Abstracts Nos. 1760 (1899) and 928 (1902).] O. J. S.

931. *Fusion of Quartz.* **R. S. Hutton.** (Manchester Lit. and Phil. Soc., Mem. 46. 2. pp. 1–5, 1901–1902.)—This paper gives some useful references to the literature of the fusion of quartz. The author repeated Moissan's experiment on the volatilisation of flint-stones in an electric furnace; he observed that the residual unvolatilised silica was very glassy, and in parts quite transparent. Further experiment showed that, provided a small current of air is allowed to pass through the furnace, no reduction of the solid or liquid silica takes place; consequently the arc can be used as a source of heat for fusing silica without fear of spoiling the results by reduction. For building up small rods, grooves are cut in a plate of graphitic carbon prepared in the electric furnace, and small pieces of quartz are placed in these grooves; they are melted together gradually from one end to the other of the grooves by sliding the plate under the arc-flame. Shapes of various kinds can be formed in a similar manner. The black stains caused by reduction can be made to disappear by bringing the heated mass for a short time away from the middle of the flame. By cutting passages in the sides of a Moissan furnace, so that a carbon support charged with quartz can be passed under and at right-angles to it, thick-walled tubes of quartz with a core about one-eighth of an inch were prepared. A 50-volt arc was used, at 300 amperes. Pure white sand fused in a similar manner gives a much more opaque mass when fused, but plastic quartz can take up a certain amount of sand without impairing the transparency. The author suggests that probably a small sand-blast, blowing sand or fine quartz, could be used for thickening bulbs and tubes of quartz fused by this method. R. A.

REFERENCES.

932. *Electrode Potentials.* **F. Haber.** (Zeitschr. Elektrochem. 7. pp. 1043–1053, Dec. 5, 1901. From the Chemisch-technischen Institut der Technischen Hochschule, Karlsruhe.)—This paper does not admit of a detailed abstract. It contains nothing essentially new, but gives a very useful discussion and summary of oxidation and reduction potentials. The "electrodes" dealt with include the following: Zinc electrode; hydrogen electrode; iodine electrode; ferrous-ferric electrode; permanganate electrode; oxygen electrode; ferrocyanide-ferricyanide electrode. F. G. D.

933. *Electrolytic Production of Alkalis.* **H. Seibert.** (Elektrochem. Zeitschr. 8. pp. 167–173, Nov., 1901.)—An account of electrolytic methods for the manufacture of alkalis, with figures of the apparatus, and calculations as to the cost of production. W. C. B.

934. *Electrochemical and Electrometallurgical Industries in* 1901. **J. B. C. Kershaw.** (Electrician, 48. pp. 421–423, Jan. 3, and pp. 462–464, Jan. 10, 1902.)

935. *Electrochemical and Electrometallurgical Industry.* **J. B. C. Kershaw.** (Elect. Rev. N.Y. 39. pp. 446–447, Oct. 12; 511–513, Oct. 26; 628–630, Nov. 23; 719–721, Dec. 14, 1901; 40. pp. 39–41, Jan. 11, 1902.)—This is a series of papers describing recent progress in the United States and Europe. G. W. DE T.

936. *Metallic Carbides.* **H. Moissan.** (International Chemical Congress at Paris, Reports, pp. 52–68, 1901.)—A summary of work done on the preparation of carbides, mainly with the help of the electric furnace, and a description of their properties. It is suggested that petroleum is formed by the decomposition of carbides. T. M. L.

937. *Recent Discoveries in Cryoscopy and Tonometry.* **Raoult.** (International Chemical Congress at Paris, Reports, pp. 23–32, 1901.)—A summary, by the discoverer of the method, of the results obtained by determining molecular weights from the elevation of the boiling-points, depression of the freezing-point, and lowering of the vapour tension of solutions. T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

938. *Superheated Steam Engine.* **H. G. Chatain.** (Horseless Age, 9. pp. 68–69, Jan. 15, 1902.)—The author points out the difficulties met with when ordinary double-acting slide or piston-valve engines are used in connection with flash boilers supplying superheated steam, and discusses the advantages of single-acting engines in which poppet valves are used for admission of the steam, and ports in the cylinder wall for exhaust, or poppet valves for both operations. The former valve arrangement is preferred from its great simplicity. The cylinders are conveniently lubricated by the splash from an oil-bath crank chamber. C. R. D'E.

939. *Steam Engines Driving Alternators in Parallel.* **M. Leblanc.** (Soc. Int. Élect., Bull. 1. pp. 497–502, Nov., 1901.)—Designers of engines intended to drive alternators have in general paid too much attention to the "coefficient of irregularity" of their engines, and have tried to make their governors as isochronous as possible; the phenomenon of electro-mechanical resonance developed when alternators are working in parallel or when an alternator is driving one or more synchronous motors, has been generally ignored. The load of an alternator coupled in parallel is not a function of the speed merely, as it is when it is running separately, but depends on the amount of its lead or lag with respect to the others. A mechanical analogue is afforded by a number of steam engines, each belted to a separate pulley on a single shaft; the driving pulleys on the engines are rigidly keyed each to its own shaft, but the pulleys on the transmission shaft are each connected to it by an elastic coupling. The load on the shaft is a function of its speed of rotation merely. Thus any engine is free to run quicker or slower than the others within the limits of its elastic coupling, and it can assume oscillatory movements with respect to the others. An engine can cease to do work, and can be pulled round by the others, if its governor is improperly adjusted; this may result in serious accidents, such as the drawing up into the cylinder of water from the condenser. As regards the influence of the elastic couplings (a subject which has been studied since 1894 by Picou, Guillaume, Arnoux, and Desroziers) it is shown mathematically that the angular motion of a pulley on the shaft with which it is thus connected can be looked upon as the superposition of a uniform motion Ω_m, which is the mean velocity of the shaft, and of a pendulum motion of a frequency proportional to Ω_m, of which the amplitude involves other factors besides the moment of inertia of the pulley; and further, under certain conditions other pendulum movements of different frequencies would be developed. To get rid of these it is not sufficient that the engine should have a small coefficient of irregularity; it is also necessary to take into consideration the harmonic terms of the expression for the torque, and to neutralise all those of a certain frequency. The oscillations, if of short period, can be damped out by purely electrical means; but this is not the case if they have a period of, say, several seconds, as they might have if caused by hunting of the governor of the engine. B. P. S.

940. *Experimental Determination of Cyclic Variation in Angular Speed of Steam Engines.* **L. E. F. David.** (Soc. Int. Élect., Bull. 1. pp. 508–519, Nov., 1901.)—The apparatus and experiments described in the paper were arranged by Weyher and Richemond, the first series of results being given to the society in July last, since when fresh experiments have been made in collaboration with Leblanc and Lorin. The paper begins with a theoretical discussion of the definition and calculation of the "coefficient of regularity" *k*, and it is explained by the aid of diagrams how to determine this coefficient, for a flywheel of given moment of inertia, from the piston pressure, the effort exerted on the connecting rod, and the effort tangential to the circumference described by the crank. From these data and the curve of resisting moments (a straight line for the more usual case of constant resistance) the excess of motive work over resisting work, or *vice versâ*, may be determined for every part of the stroke, and hence the acceleration (positive or negative) of the flywheel at any instant can be deduced.

Two definitions of *k* are given [see Abstract No 568 (1902)], the author giving the preference to $(V_{max} - V_{min})/V_{mean}$. The angle of maximum displacement, θ, is then discussed, and it is shown how the angle may be theoretically deduced. The apparatus designed for the purpose of determining it experimentally is described. At the end of the engine shaft a disc is fixed carrying on its face a sheet of smoked paper. A tuning-fork, with a point fixed upon one of its prongs, traces a sinuous curve on the revolving disc, the mean path of the tracing-point with respect to the axis of the plate being of course circular. This circle is traced by the point with the machine at rest, and another circle is also traced, outside the diagram, and concentric with it. On the outside this latter circle is divided externally into the same number of equal parts as the number of waves traced by the pointer in one revolution, and on the inside of the same circle as many unequal parts are set off by radial lines through the intersection of the wave and the median line. Thus the outer circle shows externally the uniform movement of the ideal crank, and, internally, the varying movement of the real crank. The maximum displacement of the internal and external divisions gives the measure of the angle θ. The method lays no claim to any great precision, but is sufficient to show whether the calculated value of θ is of the same order of magnitude as the true value. In the apparatus actually used it is necessary to provide against difficulties due to end play in the shaft or to the disc not being quite perpendicular to the axis of the shaft. This is done by means of a rigid arm attached to the base of the tuning-fork, which allows he latter to turn on its support and to approach or recede from the plate. A small roller fixed on the end of the arm preserves the distance between the fork and the disc constant. A large number of plates accompanies the paper, some showing actual diagrams taken with the instrument and others being curves of steam pressure, crank effort, resistance, &c., of various engines, with the resultant speed curve of the flywheel, from which the coefficient *k* is obtained by direct measurement. A table is also given with data of the engines experimented on at various times, and the value of θ found as the results of the tests, a parallel column giving calculated values of θ. The agreement between the observed and calculated values is better at light than full loads. B. P. S.

941. *Optical Method of Determining the Law of Periodic Variation in Rotary Motion.* **A. Cornu.** (Soc. Int. Élect., Bull. 1. pp. 519–529, Nov., 1901.)—The author employs a horizontal circular plate, capable of rotation about a vertical axis through its centre and carrying a cylindrical ring concentric with the axis, pierced with a series of perfectly equidistant holes. A horizontal beam of light of parallel rays is made to traverse the ring from side to side and to project its shadow upon a screen. When the ring is set rotating, a ray of light passing through a hole in the side of the ring nearest to the source of light is stopped by the material of the ring, except when a hole in the side of the ring near the screen is in line with it, and the poles being equidistant and moving, on each side of the ring, with equal velocity and in opposite directions, the result is that a line of motionless patches of light is seen on the screen. If now another ring is used, in which the holes, instead of being equidistant, are spaced so as to subtend equal angles about a point in the plate at a distance a from the centre, the author shows that the result is precisely the same as if the holes in the ring were equally spaced, but the ring itself moving, as regards the half of it near the source of light, with a velocity varying periodically according to the sine law, the half of the ring near the screen still moving uniformly. In fact, each hole in the ring, instead of occupying the position defined by the equation $x_m = x_0 + m\mathrm{C}/\mathrm{N}$ (where $\mathrm{C} =$ circumference of the ring, $\mathrm{N} =$ total number of holes, m the number, counting from zero, of the hole in question, and x_0 the distance from the origin of the hole numbered 0) now has its position defined by $x_m = x_0 + m\mathrm{C}/\mathrm{N} + \sin 2\pi(m_1 - m_0)/\mathrm{N}$, where m_0 is the number counting from zero of the hole which defines the diameter passing through the two axes. Consequently, two holes situated at opposite ends of a diameter (for which $m - m' = \mathrm{N}/2$) undergo changes of position which are equal and of opposite signs; the result being that a ray of light passing through these two holes at the most favourable position will appear to oscillate from $+a$ to $-a$ at every revolution of the ring. The author goes on to show that if R be the radius of the ring, a/R represents the angle of eccentricity in circular measure, when a is small, and this is the same thing that engineers call the angle of displacement. In order to measure the travel of the spots of light, a modification of the method above described is used. By means of two right-angled prisms a ray of light is reflected from the inside of the ring through the holes pierced in its circumference, and then through a series of equidistant holes in the edge of a uniformly revolving disc upon the sensitive plate of a camera, to which is given a regular rocking movement about an axis parallel to the series of images. The negative, when fixed, shows a series of points of light disposed in a straight line, when the image to the eye is stationary, and in the form of a sinoidal curve when the image oscillates. Measurements made on the photographic plate give the eccentricity for each of the holes in the ring; if one of these is stopped up the phase of the periodic curve can be at once determined. It is not necessary that the rotating disc should be moving with absolutely the same velocity as the ring; a slight uniform acceleration in either sense has merely the effect of making the photographic trace slightly oblique in direction; the ordinate of each point is then measured as if referred to oblique axes. In the industrial application of this method, as, for example, in analysing the velocity of a flywheel, round-headed steel studs might be arranged circumferentially on one of its faces, and illuminated by an arc lamp. A lens of suitable focus would project the circle of luminous points on to the revolving disc, and the photographic trace would be made as described. It is obvious that whatever the law of speed variation, it would be faithfully recorded; it has only been assumed to be the sine law for the sake of simplicity. As to the accuracy obtainable, the angle of displacement a/R being inversely proportional to the radius of the circle on which the luminous points are disposed, and the quantity a being of the order of two or three millimetres, displacements of a small fraction of a degree can be easily measured in a flywheel of ordinary size. B. P. S.

942. *Cyclical Speed Variation in Steam Engines Driving Alternators.* **P. Boucherot.** (Soc. Int. Élect., Bull. 1. pp. 529–553, Nov., 1901.)—This paper is a discussion of the relation between θ, the angle of maximum displacement of the flywheel of the engine driving an alternator [see Abstract No. 568 (1902)], and 1/R, the irregularity; this quantity is defined as the ratio of the difference between the maximum and minimum angular speeds and twice the mean angular speed. The cases discussed are those of an *isolated set*, or an engine driving an alternator singly, and a *coupled set*, the engine and alternator being supposed connected in parallel on infinite mains of constant frequency. The influence of the engine governors is, for the present, left out of account. The simple case first considered is that in which the function connecting angular velocity and time is a pure sinoidal curve superposed on a straight line; it is shown that in this case $\theta = 1/n\mathrm{R}$, where n is the number of impulses per turn corresponding to variations in the torque. Thus for a single cylinder engine $\theta = 1/2\mathrm{R}$, or the angle of maximum displacement is one-half the irregularity. In most cases, unfortunately, the function connecting speed and time is a complicated Fourier series. In this connection the author refers to a series of 28 diagrams, which are reproduced, and which were supplied by four different engineering firms, and relate to engines of various types, with one, two, and four cylinders, and of which the sizes go up to 1,500 h.p. These diagrams, which show graphically the relation between turning moment and time, have been analysed by the author and expressed in Fourier's series; a table is given showing the values of the coefficients of the first eight terms. Some of these curves are discussed at length, and the values of θ, calculated from the irregularity by means of the Fourier's series, are compared with the values assigned by the engine builders, the results being very concordant. The author then discusses the mathematical theory in the case of "coupled" sets, and shows that, contrary to the usual belief, the angle of displacement, in the case of alternators running in parallel, is *increased* where there is damping. It is shown that the ratio σ of θ coupled (no damping) to θ isolated, can be expressed very simply as $\sigma = \mathrm{W}/(\mathrm{W} - \mathrm{W}_r)$, where W is the *vis viva* of the flywheel ($= \frac{1}{2}\mathrm{I}\Omega^2_{mean}$) and W_r the corresponding value when there is resonance. In a particular case, a table is given showing values of σ corresponding to different values of the alternator reaction; this latter quantity being measured by the ratio of the normal current to that on short-circuit.

The conclusion reached by the author is that for safe parallel running it is unwise to allow such a large angular displacement as is sometimes assumed to be safe. The effect of damping is considered, and its influence (especially near the point of resonance) in causing the increase of the flywheel action to *increase* the ratio σ is deduced. The latter part of this important paper is taken up with a discussion of the influence of the higher harmonics in the Fourier's series, both in the case of an alternator running on mains in which the frequency is rigidly constant, and in that of two alternators coupled together. Summing up his results, the author believes that the period of oscillation of an alternator can be calculated with an exactitude which is sufficient for practical purposes. B. P. S.

943. *Calculation and Measurement of the Angle of Displacement of a Rotating Flywheel.* (Soc. Int. Élect., Bull. 1. pp. 584–600, Dec., 1901.)—This is a report of the discussion on the last four papers. **Rateau** objected that the theories on which the calculation of θ had been based, assumed the resisting couple to be constant; in the case of an alternator this is not so; however, the error is negligible except in the case of a small number of poles. With alternators in parallel, it is not the angle θ of one machine which should be considered, but the difference $\theta - \theta'$ between the angular displacements of the two coupled machines. In the case of alternators with different numbers of poles, when these numbers are prime to each other pendular movements of long period may be set up. The method described by Cornu is more suited to the laboratory than the workshop; for the latter a mechanical rather than an optical method is preferable. If on the shaft to be tested a carefully cut bevel wheel is fixed, and on the prolongation of the axis a similar wheel is arranged on another shaft provided with a flywheel and kept in uniform rotation (by means, for example, of an electro-motor) in the opposite direction, then the movement in either direction of a third wheel geared between the two would, provided the mean speeds of the two shafts are the same, be a measure of the angular displacement of the first shaft at any instant. To give sensitiveness, the motion of the first shaft should be geared up by a train of spur wheels. If the mean speed of the uniformly rotating shaft be different from that of the shaft under test, the third wheel will have a movement of *precession* as well as of *nutation*; it is the amplitude of the latter which gives the value of θ sought. **Cornu** defended his method against the charges of want of sensitiveness and unsuitability for workshop practice. An accuracy of the order of 2 minutes of arc can be easily reached with a flywheel 4 metres radius; and all the arrangements necessary for the stroboscopic method can easily be carried out by a good mechanic. **Boucherot** did not admit that the variation of the resisting couple in the case of a flywheel alternator would materially alter his equations, this factor being really of less importance than others which he had deliberately omitted as being negligible. In practice, flywheel alternators have a sufficient number of poles to make the resisting couple quite uniform. As for Rateau's second objection, the case of two alternators in parallel has already been treated in the Bulletin. **Dubois** suggested a modification of Rateau's method by which the electro-motor used for maintaining the uniform rotation of the shaft with the flywheel might be dispensed with, the spindle of the third wheel being attached to a spring of which the other end would be fastened to a fixed point. **David** thought that so far as his own method was concerned any attempt to magnify the angular displacement of the shaft by means of gearing would introduce great difficulties, illustrating his point by a concrete example. The precision attainable by his method he estimated as of the order of $\frac{1}{10}$th of a degree. **Hospitalier** would use the main shaft in Rateau's method to impart a uniform velocity to the second shaft, which he would drive from the former by an elastic coupling. The inertia of the flywheel keyed to the latter would give a practically uniform speed.

B. P. S.

944. *Measurement of Variations in the Angular Velocity of the Flywheel of an Otto Gas Engine by the Stroboscopic Method.* **A. Cornu.** (Soc. Int. Élect., Bull. 2. pp. 50–56, Jan., 1902.)—On the flywheel, which was about 1·8 m. in diameter, there were fixed at equal distances on a layer of mat varnish eighteen discs of tinfoil about 2·2 cm. diameter. The discs on the upper segment of the flywheel were illuminated by the light of an arc lamp projected from an optical lantern. A lens of 15 cm. focal length, at a distance of 2·1 m. from the flywheel, projected the image upon a rotating disc, so that the illuminated segment of the flywheel coincided with a portion of the circumference of the disc, which was pierced with 36 round windows, and rotated by an electromotor. (In another series of experiments, a larger disc was used actuated by clockwork.) By means of a brake the speed of the disc could be regulated to a nicety, so as to be equal to, or half or double, that of the flywheel. Oscillations of the image were thus produced in the plane of the disc ; these were registered photographically on a gelatino-bromide plate. To obtain the law of oscillation with time, the image was spread out proportionately to the time by a mirror rotating about a horizontal axis placed directly in front of the objective. Some of the plates thus obtained are reproduced in the paper ; they take the form of a series of curves concave to the horizontal axis, joined at the bottom by curves of small radius in the reverse direction. By the device of covering one of the tin-foil discs (that situated on the prolongation of the crank) with black paper, and thus eliminating one point on the curve, it is seen that the lowest point of the curve corresponds to the moment when the crank is vertical and upwards. This is the instant at which the explosion occurs in the cylinder. In the photographs the point of light at the apex of the curves is also seen to be missing ; this is because the explosion occurs only at alternate strokes. It was found that images of much better definition could be secured by using small bright hemispheres on the flywheel to reflect the light, instead of tin-foil discs ; when this substitution was made, very accurate measurements could be made by means of a Bianchi micrometer. A table is given showing the results of these measurements, which are taken to the $\frac{1}{100}$th part of a millimetre. The maximum displacement of the points of light from the mean position is 5·08 mm. ; the mean distance between two parallel curves is 7·79 mm., representing an angle of 20° (since there are 18 bright points on the circumference of the flywheel). Thus the maximum angle of displacement, which occurs every second stroke where the explosion takes place, is (5·08/7·73) × 20° or 13°·04. [See also Abstract No. 941 (1902).]

B. P. S.

945. *Measurement of the Variation in Angular Velocity of a Flywheel by Sartori's Stroboscopic Method.* **J. Blondin.** (Soc. Int. Élect., Bull. 2. pp. 57–65, Jan., 1902.)—This paper begins with a short discussion of the various methods—mechanical, electrical, optical—which have been employed to determine the periodic variations in speed of a flywheel, the conclusion arrived at being that the optical method is the only one which gives satisfactory results. A ray of light has no elasticity or inertia which could introduce errors into the results, and by means of photography the most rapid variations can be registered. Mechanical accessories being reduced to a minimum, experimental errors are also proportionately reduced ; and lastly, the variations in speed of the *rim* of a flywheel, and not merely of the shaft, can be measured stroboscopically, the two things being only identical when the elasticity of the arms of the wheel is negligible. In the method devised by Sartori two discs are employed, each pierced with slots cut exactly to the evolute of a circle, the curvature being in opposite directions in the two discs. If these are then placed so that their axes are in the same straight line, with a strongly illuminated screen behind them, a number of luminous points will be seen, resulting from the intersection of the two series of slots ; these points are disposed along a circumference, the radius of which depends on the relative position of the two discs. When the discs are rotated in the same direction with equal angular velocity, a circle of light is seen ; if one disc moves more rapidly than the other, this circle expands or contracts, the increase or decrease of the radius being, owing to the shape of the slots, proportional to the angular displacement of the discs. In a trial of the method upon a 250-kw. Tosi-Ganz steam alternator at the Central Station at Trieste, one of the discs was rotated by a small electro-motor worked from secondary cells, so that the rotation was perfectly uniform ; the other was driven by friction by means of a bicycle wheel clamped to the shaft of the alternator. The variations of velocity of the shaft were thus magnified in the disc in the proportion of about six to one. The alternator was running at the time of the test in parallel with another precisely similar set ; the speed of the shaft was 104 and that of the disc 665 r.p.m. ; a variation of 10 mm. in the radius of the luminous circle corresponded to a displacement of 0·24 degrees between the two discs, and the result of the test was to give a variation of 16 mm. radius. The maximum displacement of the alternator shaft as compared with the ideal (uniformly rotating) crank was thus found to be $\frac{1}{2} \times 1{\cdot}6 \times 0^{\circ}{\cdot}24 = 0^{\circ}{\cdot}19$. These alternators are therefore well suited for parallel running, as indeed is proved by the fact that they run in perfect synchronism with another 500-kw. set of which the engine also drives a direct-current dynamo supplying 200 kw. for tramway service. Under these conditions, however, it was found impossible with the stroboscopic discs to get perfect steadiness of the luminous circle ; but with alternators driven independently, almost perfect steadiness was attained and the observations were easy. The law of variation of speed can be registered photographically by means of a revolving mirror. The limit of accuracy is stated by Sartori to be about 3 per cent., but the author thinks this a somewhat optimistic figure ; in any case, however, the method is a useful one, and well adapted for the workshop as well as for the laboratory. B. P. S.

946. *Errors of the Indicator Diagram.* **L. C. Wolff.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1772–1779, Dec. 14, 1901.)—The author enumerates errors which are liable to occur in indicator diagrams, and concludes that the i.h.p. calculated from diagrams cannot be relied upon to the extent usually assumed, even for slow-speed engines, while for high-speed engines the figures obtained are grossly inaccurate. The chief sources of error increase with the speed, and are : (1) Error in the pressure indicated, according as the pressure is rising or falling, or other variation occurring in the conditions. Springs in tension, and not in pressure, are recommended. (2) Possible synchronism between the spring's natural period of vibration and the period of the force exerted on it. The steam also has a period of vibration which may assert itself. (3) Frictional resistance to the flow of steam in the indicator pipes giving rise to a lag in the indicated pressure. (4) Variation in the length of the diagram due to stretching of the string. The effect will not be the same at both ends of the diagram.

Sets of tests were made on a small ungoverned engine, with the speed varied from 100 to 1,000 r.p.m., and various indicator springs and pressures. The b.h.p. could not be measured. The engine was single cylindered. Diagrams are given and discussed. The conclusions arrived at are : (1) The isothermal coincides more closely with the actual expansion curve as the speed rises. (2) The compression curve coincides less closely with the isothermal as the speed rises. (3) The length of the diagram increases with the speed, especially on the near dead point. (4) Allowance should be made in the indicating gear for the thickness of the string (5 mm. say). (5) The i.h.p. calculated from the diagrams varies, at constant speed, with individual indicators and springs. (6) After - admission increases with the speed. (7) The indicated admission line falls with an increase of speed; (8) so does the initial and final pressure. (9) The pressure on the dead point first rises and then falls with the speed. (10) The compression curve gradually disappears with rising speed. R. C. R.

947. *Pipe-Covering Tests.* **G. H. Barrus.** (Power, N.Y. 21. pp. 32–33, Dec., 1901.)—The object of these tests was to ascertain the efficiency of various kinds of non-conducting coverings for steam-pipes, as determined by the weight of water or condensed steam produced in the pipes. Two sections each 100 ft. long, of standard 2-in. steam-pipes were employed, one for steam of 150 lbs. pressure and one for steam of 80 lbs. pressure. In the 150 lbs. section two 10-in. pipes, each 35 ft. long, were used, in order to test the effect of difference of size. The tests were continued for from eight to nine hours each day on consecutive days, so that many of the coverings were tested day after day for a period of a month, and every one was subjected to at least three days' continuous run. Precautions were taken to start with dry steam, to measure accurately the water produced by condensation, and to observe the temperature and humidity of the air.

MINIMUM AND MAXIMUM RATES OF CONDENSATION IN LBS. PER HOUR FOR EACH OF THE COVERINGS TESTED.

Order of Merit.	2-in. Coverings, 80 lbs. pressure.	Minimum.	Maximum.
1	John's Asbestocel	13·46	14·07
2	New York Air Cell	13·88	14·14
3	Carey's Moulded	14·18	15·00
4	John's Moulded	14·15	15·07
5	Gast's Ambler Air Cell	14·60	15·14
	2-in. Coverings, 150 lbs. pressure.		
1	John's Asbesto-Sponge Hair Felt, 3-ply	10·47	10·93
2	" " " " 2-ply	11·21	11·29
3	Asbestos Sponge Felted (Sectional)	11·20	11·57
4	K. and M. Magnesia (85 per cent. Magnesic Carb.)	11·64	12·20
5	Asbestos Fire Felt (Navy Brand)	13·18	14·00
	10-in. Coverings, 150 lbs. pressure.		
1	John's Asbesto-Sponge Felted	10·67	11·07
2	K. and M. Magnesia (85 per cent. Magnesic Carb.)	13·00	13·64
3	Asbestos Fire Felt (Navy Brand)	14·00	14·64
4	Watson's Imperial	15·79	15·93
	Bare pipes.		
	2 in., 80 lbs. pressure	55·75	60·30
	2 in., 150 lbs. pressure	71·78	72·20
	10 in., 150 lbs. pressure	105·9	112·00
	Temperature of air (approximate)	50°	75°

There were no appreciable currents of air in the test-room. No difference in result was obtained when steam was allowed to flow through the pipes at a velocity of 18 ft. per second from those yielded when the steam was practically still. The accompanying table gives the order of efficiency of the coverings tested for each size and pressure and the maximum and minimum rates of condensation per hour for each. The condensation from the pipes without covering is also given for comparison. F. J. R.

948. *Forced Draught.* **W. H. Booth.** (Cassier, 21. pp. 130–139, Dec., 1901.)—The author expounds this subject from its elements, showing how ordinary chimney draught is produced, and what are its limitations and defects under such circumstances as those of an electric light or power-station, and what is the power represented by a given chimney draught. The fundamental rules governing the quantity of air required for combustion, and the velocity of gases, are dealt with and applied to show the advantages of forced draught by fans. The different systems, viz., by means of the closed stokehold, the closed ashpit, and the induced method, are shortly described, and for land installations preference is given to the latter for various reasons, whilst the others are more useful for marine work. Some figures are given to show the economy in first cost, in power, in working costs, and in upkeep resulting from fan draught, and the author sums up by declaring that "the system of artificial draught is one that, no matter how approached, presents a favourable appearance to the experienced engineer. It is cheap to instal and cheap to run, the power to work the fan being but a small part of the economy to be gained by its use. Not merely is the first cost small, but there is a further capital economy in the reduction of boilers or their substitution by feed-water heaters. And upon all there is the added convenience given by the facility of extending the plant, the freedom from the paralysing influence of the insufficient chimney, and the entire freedom from meteorological influence." F. J. R.

949. *Town Refuse Disposal in Great Britain.* **W. F. Goodrich.** (Cassier, 21. pp. 99–122, Dec., 1901.)—The author gives a historical sketch of the introduction of destructors, beginning with Fryer's in 1876, and then describes and illustrates the Fryer destructor at Cambridge, Warner's destructor at West Hartlepool, Baker's at Clerkenwell and Lambeth, Meldrum's at Nelson, Horsfall's at Fulham, Heenan's twin-cell destructor at Blackburn, Mason's refuse gasifier, and the Beaman and Deas' destructor at Colne. The importance of the matter to any locality may fairly be judged from the fact that from 15 to 20 cwts. of refuse are produced daily by each 1,000 of the population. In some cases the evaporative value of the refuse is as high as $\frac{1}{5}$th of that of coal, but the percentage of value differs with various kinds of refuse and different destructors, varying from $\frac{1}{5}$th to $\frac{1}{15}$th. Where the evaporative value is less than $\frac{1}{16}$th that of coal the destructor cannot well be reckoned as a power producer. In order to analyse the performance of different destructors, several Lancashire towns are selected in which the calorific value of the refuse may be presumed to be pretty uniform, and the results from these are given in the table on page 406.

In other Tables in this article are given full records of results of a twenty-four hours' test of the St. Domingo destructor at Liverpool, of one month's continuous work of the Meldrum destructor at Nelson and of a test of shorter duration in which the plant was forced, without sacrifice of the general efficiency, of a test of Heenan's destructor at Blackburn, and of Beaman and Deas' destructor at Canterbury. In all these cases the fuel value of the refuse for evaporation or steam raising, and the soundness of the principles on which these British destructors have been constructed, are demonstrated. F. J. R.

Town.	Evaporation per lb. of Refuse.	Average Steam Pressure.	Temperature of Feed Water.	Consumption of Refuse per Cell per 24 Hours.					I.H.P. Produced per Ton on Basis of 20 lbs. Steam per I.H.P.	Duration of Test.	No. of Cells or Grates in Use.	Rate of Combustion per sq. ft. of Grate per Hour.	Boilers in Use.
		lbs.	Deg. Fahr.		t.	c.	q.	lbs.				lbs.	
Oldham	0·880	123	212	1 cell	= 7·96 tons				98	24 hours	10 cells	25	2 Lancs. 30′ × 8′
Ashton-under-Lyne	0·783	122	212	1 „	= 9·97 „				87	24 „	6 „	31	2 Multitubular
Bury	0·532	—	53	1 „	= 9				59·584	4 „	6 „	33·6	3 „
Rochdale	1·78	114	212	4 grates	= 50	15	1	4	199	6½ „	4 grates	54·9	1 Lanc. 30′ × 8′
Darwen	1·55	193	212	4 „	= 52	2	1	6	178·6	48 „	4 „	56	1 „ „
Nelson	1·516	118	212	4 „	= 61	0	0	0	169·792	9¼ „	4 „	57	1 „ „
Nelson	1·85	120	212	4 „	= 81	0	0	0	207·2	1 month	4 „	29	1 „ „
Nelson	1·95	122	212	4 „	= 78	4	0	0	218·4	8 hours	4 „	68·5	1 „ „
Blackburn ...	1·89	90·8	212	2 „	= 25	9	1	12	155·68	12 „	2 „	48	1 „ 24′ × 7′
Fleetwood ...	1·19	185	212	1 cell	= 21	11	2	2	188·28	8 „	2 cells	80·5	1 Babcock W.T.
St. Helens ...	1·54	127	212	1 „	= 27	12	0	8	172·48	7 hr. 20 min.	2 „	108	1 „ „
Warrington ...	1·14	68	104	1 „	= 28	0	0	0	127	24 hours	2 „	88·48	1 „ „
Blackburn ...	1·297	122·8	212	1 „	= 11	8	0	12	145·264	7 hr. 40 min.	4 „	84·66	2 Heenan W. T.
Liverpool ...	1·178	—	212	1 „	= 16	10	0	0	181·876	24 hours	8 „	62·16	4 Babcock W.T.

950. *Comparative Tests of Coal and Crude Oil as Fuel.* (Eng. News, 47. pp. 80–82, Jan. 30, 1902.)—This article contains an abstract of the Report by Prof. Denton, of the Stevens Institute of Technology, Hoboken, N.J., of a series of experiments with American coal and with Texas oil as fuel under a cylindrical return tubular boiler 6 ft. diameter by 18 ft. long, one of three in the boiler-room of the American Ice Company. An illustration of the arrangement of boiler furnace and oil supply is given, and also sectional details of the oil-burner used, which was on the familiar steam-jet injector lines. The oil was sprayed against a block of firebrick chequer-work in the furnace, and means were introduced for partially heating the air for combustion. The average quality and composition of the oil were as follows: Specific gravity, 0·920; flash point, 142° F.; burning-point, 181° F.; cold test —6° F.; calorific value per lb. by oxygen calorimeter, 19,060 B.Th.U. Composition: Carbon, 80·60 per cent.; hydrogen, 10·90 per cent.; sulphur, 1·63 per cent.; nitrogen, 0 per cent.; oxygen, 2·87 per cent. The coal used was a high grade of No. 1 Buckwheat (anthracite) coal, containing approximately: Moisture, 6·2 per cent.; ash, 11·6 per cent.; carbon, 77·5 per cent.; hydrogen, 2·0 per cent.; sulphur, 0·5 per cent.; oxygen and nitrogen, 2·2 per cent. The amount of ash resulting from the actual firing of the coal was from 16 to 18 per cent. of the total fuel. With cold brickwork and water in the boiler at 64° F. steam was raised to 85 lbs. pressure in 59 minutes with oil fuel, and in 1 hour 17 min. with coal. The draught was that which was due to a chimney 70 feet high by 42 in. square. The results of these tests are given in Table I., page 408.

In comparing the relative costs of oil and coal for producing power on the ordinary basis of 1 h.p. per 10 sq. ft. of heating surface and with average percentage of ash and moisture in coal, the evaporation per lb. of wet coal from and at 212° F. = 8·75 lbs.; the net evaporation per lb. of oil from and at 212° F. = 14·8. Ratio of oil to coal $\frac{14{\cdot}8}{8{\cdot}70} = 1{\cdot}69$. Number of barrels of oil equivalent to 2,240 lbs. coal = 4·12. Price of coal per long ton, no haulage or ash removal, = $3.00. Equivalent price of oil per barrel of 42 U.S. gallons, = $0.73. Table II., page 409, gives the cost of oil as compared with coal of various qualities. F. J. R.

GAS AND OIL ENGINES.

951. *Spark Control.* **A. L. Clough.** (Horseless Age, 9. p. 99. Jan. 22, 1902.)—The author points out the deficiencies in the present system of fitting a hand adjustment to the spark-timing apparatus attached to motor vehicle engines, and advocates the use of a timing apparatus controlled automatically by the engine, which would then itself determine the most advantageous point of igniting the charge for any condition of load. The throttle valve would then give the only necessary hand control for the engine. C. R. D'E.

952. *Vilain Cooling System.* (Horseless Age, 9. pp. 109–111, Jan. 22, 1902.)—This is a thermosyphon cooling system in which a coil of copper tubing mounted above the top of the engine cylinder has its ends connected to the top and bottom of the cylinder water-jacket. The tubing forms a closed circuit, no water-tank being necessary. It is calculated that if the copper tubing has a radiating surface of ten times the surface of the cylinder walls, its radiating power, when standing still, will keep the temperature of the jacket at 128° C. = 2·5 atmospheres pressure. A safety valve is fitted. There is no evaporation, so the water lasts indefinitely. About 1 gallon of water is carried. C. R. D'E.

TABLE I.

RÉSUMÉ OF TESTS.

DIMENSIONS OF BOILER: 6 ft. diam., 18 ft. long; 100 Tubes, 2¼ ins. in diam.; Grate Surface, 45·5 sq. ft.	BEAUMONT CRUDE OIL.					NO. 1 BUCKWHEAT COAL.	
	Nov. 27.	Night of Nov. 27–28.	Nov. 28.	Night of Nov. 28–29.	Nov. 29.	Dec. 12.	Dec. 13.
Duration, hours	3·5	8	11	13	11	12	12
Horse-power	146·9	112·7	189·7	138·0	220·1	92·6	119·1
Steam pressure (gauge), lbs.	87	86	86	86	86·5	84·5	86·5
Feed temperature, deg. F.	69	90	70	90	74	68	72
Chimney temperature, deg. F.	374	360	398	370	425	389	396
Quality of steam	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Moisture in coal	...	...	...	...	...	6·2 %	6·2 %
Per cent. of ash	...	...	...	...	...	16·2 %	18·0 %
Times fire was cleaned	...	...	...	...	...	Once	Twice
Coal per hour per sq. ft. of grate, lbs.	...	...	...	...	...	7·66	10·10
Coal per sq. ft. of heating surface, lbs.	...	...	...	...	...	0·182	0·247
Oil per hour per sq. ft. of heating surface, lbs.	0·181	0·135	0·226	0·163	0·263	...	...
Dry steam per hour[1] per sq. ft. heating surface, lbs.	2·73	2·09	3·52	2·56	4·08	1·72	2·21
Heating surface per h.p. sq. ft.	12·6	16·5	9·8	13·5	8·45	20·1	15·6
Total dry steam per lb. of fuel as fired,[1] lbs.	15·29	15·53	15·55	15·71	15·49	9·17	8·94
Per cent. of steam used by burner[2]	3·6	3·1	4·8	3·5	4·8	...	...
Net lbs. of dry steam per lb. of fuel as fired[1]	14·74	15·05	14·80	15·16	14·75	9·17	8·94

[1] From and at 212° F.

[2] The steam used by oil pump was fraction of one-tenth of 1 per cent., and is therefore not considered.

TABLE II.

COMPARATIVE COSTS OF OIL AND COAL.

Items.	Bituminous Coals mined West of Ohio, and used in Western and South-western States.	Small Sizes of Anthracite.				Pittsburg bituminous used in Mills of Pennsylvania and on Great Lakes.	Semi-bituminous : Atlantic Ocean Traffic ; Mills of Eastern and Middle States.		
		Culm.	No. 3 Buck-wheat or Barley.	No. 2 Buck-wheat or rice.	No. 1 Buck-wheat or pea.		Hand-fired.	Mechanical Stokers and Patent Furnaces.[1]	
								Ash, 10 %.	Ash, 5 %.
1. Pounds evaporation per lb. wet[2] coal, from and at 212°, at about 10 sq. ft. of heating surface per boiler h.p.	7·5	7·75[3]	8·25[3]	8·50[3]	8·75	9·50	10·00	10·50	11·00
2. Pounds evaporation per lb. of Beaumont oil from and at 212°, at about 10 sq. ft. of heating surface per boiler h.p.	14·8	14·8	14·8	14·8	14·8	14·8	14·8	14·8	14·8
3. Ratio of evaporation of oil to coal = Line 2 ÷ Line 1 = R.	1·97	1·91	1·79	1·74	1·69	1·56	1·48	1·41	1·35
4. No. barrels oil = to 2,240-lb. ton wet coal = 2,240 ÷ (322[4] R) = N.	3·54	3·64	3·90	4·00	4·12	4·46	4·70	4·94	5·15
Equivalent price of oil per barrel of 42 U.S. gallons = $P_c \div N = P_o$.									
5. Price of coal, per ton of 2,240 lbs. P_c $1.00	$0.29	$0.28	$0.26	$0.25	$0.25	$0.23	$0.21	$0.20	$0.19
6. 1.50	0.43	0.41	0.39	0.38	0.36	0.34	0.32	0.30	0.29
7. 2.00	0.56	0.55	0.51	0.50	0.49	0.45	0.43	0.40	0.39
8. 2.50	0.71	0.69	0.64	0.62	0.60	0.56	0.53	0.50	0.40
9. 3.00	0.85	0.82	0.77	0.75	0.73	0.67	0.64	0.60	0.58
10. 3.50	0.99	0.96	0.90	0.87	0.85	0.78	0.75	0.71	0.68
11. 4.00	1.13	1.10	1.02	1.00	0.97	0.90	0.85	0.81	0.77
12. 4.50	1.28	1.23	1.16	1.13	1.09	1.01	0.96	0.91	0.87

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[1] Mechanical stokers and patent furnaces introducing air over fire.

[2] By "wet coal" is meant coal containing 3 per cent. of water.

[3] These figures are net evaporation after allowing for steam consumed to produce the forced draught necessary for burning the fuel.

[4] Weight of oil per gallon = 7·66 lbs.; weight of oil per barrel of 42 U.S. gallons = 322 lbs.

953. *Manograph (Optical Indicator) of E. Hospitalier and J. Carpentier.* (Ind. Élect. 11. pp. 9–11, Jan. 10, 1902.)—This apparatus is designed to trace indicator diagrams giving the continuous variation of pressure in gas and oil engines at speeds up to about 2,000 r.p.m. An indicator of a similar character was made by Perry, suitable for a steam engine at speeds of 500 or 600 r.p.m. The manograph indicator, Fig. 1, is separated from the motor, to avoid vibrations, and the pressure of the gas is transmitted by a flexible copper tube T, Fig. 2, whilst a flexible connection gives the rotation of the motor-shaft. A little mirror rests on three points A, B, C, forming a right-angled triangle. The point A at the right angle is fixed, and about it the mirror turns; B is moved normal to the plane of the mirror, and in proportion to the pressure, by one end of a rod, the other end of which rests on an elastic metallic disk M, Fig. 2, acted upon by the fluid pressure. The point C moves the mirror in proportion to the travel of the piston. Springs are fixed behind the mirror to keep it pressed against the three points of support. A beam of light from a small acetylene flame is projected by a prism on to the little mirror, Fig. 1, which reflects it on to a screen, giving diagrams 10 cm. in length and 7 to 8 cm. high. The impressions on the retina make the diagram appear in the form of a continuous curve. Indicator diagrams are given as traced by the spot of light. With very small moving masses, and only slight motion, indicator diagrams are shown from an alcohol motor of De Dion and Bouton, running at 2,200 r.p.m. In an engine having a cylinder 8·4 cm. diameter by 11 cm. stroke the speed was 1,800 r.p.m., and the mean pressure 4·845 kilos per sq. cm. (equal to 61·8 lbs. per sq. in.), while the output of a dynamo driven by it was 8,300 watts. W. R.

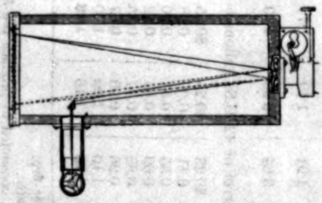

FIG. 1.

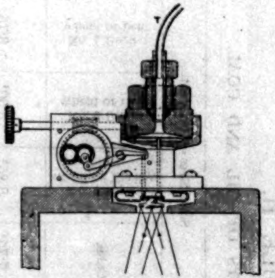

FIG. 2.

954. *Desvignes Ether Vapour Generator.* (Scientific American, 86. pp. 9–10, Jan. 4, 1902.)—This generator consists of two rectangular end chambers of sheet steel, connected by numerous copper tubes slightly inclined to the horizontal, and heated externally by a gasolene furnace placed below the generator. In order to guard against a sudden generation of vapour at very high pressure a safety device is employed, by which the ether is forced out of the generator when the pressure exceeds a certain predetermined value. This apparatus consists of a closed reservoir, normally about half full of ether, and connected to one of the end chambers of the boiler below the ether level by a pipe which projects into the reservoir, and which is closed by a ball valve. Air is pumped into the reservoir, above the ether level, to a pressure equal to the maximum pressure which is desired in the boiler. If the boiler pressure exceeds this value the ether is driven out of the boiler into the reservoir, the ball valve being lifted by the excess of pressure from below, and kept open, after the boiler pressure has fallen, until the ether level in the reservoir has returned to its normal value. The initial level of ether in the boiler is maintained by a special magnetically controlled device contained in a chamber connected with a vapour drum mounted above the boiler tubes, and connected to one of the end chambers above the liquid level. The main supply to the engine is taken from the vapour drum. After performing its work in the engine the vapour is condensed and returned to the boiler by a feed-pump. The mechanism of a motor vehicle employing an ether generator of this type is illustrated; the generator weighs 265 lbs., and is capable of supplying a 10-h.p. engine. C. R. D'E.

AUTOMOBILISM.[1]

955. *Marks Steam Delivery Waggon.* **J. W. Jones.** (Horseless Age, 9. pp. 49–50, Jan. 8, 1902.)—This vehicle has a tubular underframe, which couples the front and rear axles, and from which the van body is supported by elliptic plate springs front and back. The boiler is of the combined water-tube and fire-tube type, fired by a kerosene burner. The heating surface is 45 sq. ft. Steam at 200 lbs. per sq. in. is supplied to two horizontal compound engines mounted on the underframe and driving the rear road wheels by internal spur gears. The engines have single-acting cylinders and a special form of steam distributing valve operated by a gear of the Marshall type. The only lubrication for the engines is effected by splash from the crank enclosing chambers. The total weight of the vehicle with 50 gallons of water and 18 gallons of kerosene is 4,000 lbs. C. R. D'E.

956. *Flinn's Compound Engine and Steam Carriage.* (Horseless Age, 9. pp. 81–83, Jan. 15, 1902.)—This engine has cylinders 2½ in. and 4¼ in. bore respectively × 4 in. stroke. The cylinders are vertical, and steam is distributed by piston valves located between them. By means of a special distributing valve, high-pressure steam may be admitted to the l.p. cylinder. Its general construction is calculated to secure greater durability than is common with these light steam car engines. The carriage—known as the Volomobile—carries two persons, and weighs 1,200 lbs. with 22 gallons of water and 4¼ gallons of petrol. Transmission to the live rear axle is by a single chain reduction gear. C. R. D'E.

957. *Renault Light Carriage.* (Horseless Age, 9. pp. 19–20, Jan. 1, 1902. From La France Automobile.)—The 1902 type Renault carriage with tonneau body to seat four persons is described. It has a single-cylinder vertical water-cooled engine, located at the front end of a rectangular tubular underframe, which is supported from the axles by single plate springs. The engine is enclosed by a bonnet, which forms both tank and radiator of the water-cooling system, the circulation being on the thermosyphon principle. The power is transmitted through a cone clutch to the change-speed gear, which gives three forward and one reverse speed by spur wheels brought into mesh radially, as in the back gear of a lathe. The final transmission is by a jointed tail-shaft to a bevel gear on the live rear axle. Wheel steering operating

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[1] Electric Automobiles are described in the Section dealing with Electric Traction.

through a rack and pinion is employed. The change speed and brake levers are mounted on the frame at the driver's right hand. A side and front elevation, and a plan of the arrangment of mechanism are given.
C. R. D'E.

958. *Turrell Gasoline Carriage.* (Horseless Age, 9. pp. 41–42, Jan. 8, 1902. From the Motor Car World.)—In the 1902 type the engine is located towards one side of the channel steel underframe, with centre line of crank-shaft at right-angles to the length of the frame and somewhat to the rear of its centre of length. The transmission is by bore clutch to a change-speed gear in which the spur wheels are always in mesh, and thence by a double roller chain to the exterior of the differential gear on the live near axle. The engine has two horizontal cylinders 4·5 in. bore by 4·5 in. stroke, and is rated at 7 b.h.p. at 750 r.p.m. The underframe in this vehicle has been designed especially with a view to eliminate disturbances of the engine and transmission gear centres. C. R. D'E.

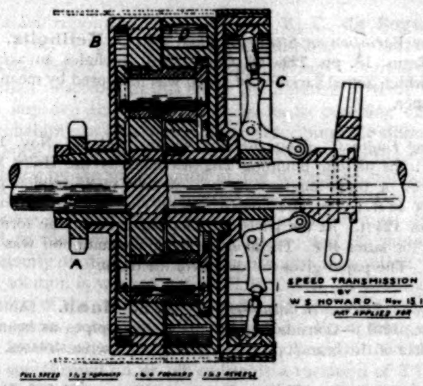
959. *Riegel Fore Carriage.* (Horseless Age, 9. pp. 74–75, Jan. 15, 1902. From La France Automobile.)—This is a two-wheeled tractor which may be attached to the locking plate of any ordinary carriage. Its mechanism comprises a double-cylinder horizontal petrol engine of 10 h.p. and a bevel and spur wheel gearing to the wheels of the tractor, which run on the ends of a fixed axle. The crank-shaft of the motor lies at right-angles to the axle, and carries at its back end the flywheel and at the front end a bevel pinion gearing with a bevel wheel on a counter-shaft parallel to the axle. On this shaft are keyed four spur pinions; these run in mesh with spur wheels which are mounted free on a second shaft, from which the power is finally transmitted by spur gears to the road wheels. The free spur wheels of the change-speed gear may be locked to their shaft by means of electromagnetic clutches supplied with current from a small storage battery of 60 ampere-hours at 4 volts, which also supplies the electric ignition of the engine. The counter-shaft for the final drive is in halves, and by a special arrangement of clutches either of the road wheels may be driven independently. The vehicle is steered by causing one or both wheels to become drivers. All the operations of the mechanism of the tractor are controlled electrically from the steering pillar, and the connections between carriage and tractor are therefore very simple. C. R. D'E.

960. *Hurtu Light Carriage.* (Horseless Age, 9. pp. 108–109, Jan. 22, 1902. From La France Automobile.)—This vehicle has a rectangular tubular underframe spring from the front and rear axles by semi-elliptic plate spring. The engine, which may be either single or double cylinder, is of the vertical water-cooled type, and is enclosed by a bonnet at the front of the frame. The change-speed gear is of the sliding spur-wheel construction, giving three forward and one reverse speed. It is enclosed in an aluminium gear box, mounted as close as possible to the engine. The power is delivered to it through a cone friction clutch, and is conveyed from the change-gear counter-shaft by a flexible tail-shaft to the differential, which is suspended in front of and from the fixed rear axle. The differential is coupled by jointed rods to short shafts which run in bearings attached to the fixed axle, and which carry spur pinions engaging with internal spur-wheel rings on the rear-road wheels. The rear-wheel band brakes are applied on the exterior of these toothed drums. Steering is controlled by a hand wheel mounted on an inclined

pillar, and operating through a worm and section gear. The weight of the carriage with body varies from 1,100 to 1,800 lbs. The wheel base is 72 in., and gauge 48 in. All four wheels are 30 in. diameter. Several illustrations of the arrangement of mechanism are given. C. R. D'E.

961. *Howard Speed Change-Gear.* (Horseless Age, 9. pp. 83–84, Jan. 15, 1902.)—This is a compact form of epicyclic gearing giving three speeds forward and one reverse, its construction will be readily understood from the accompanying diagram.

When clutch *c* is thrown in the gearing is locked, and the full speed of the engine transmitted to the chain pinion A. For the intermediate speed the clutch is released and a band brake applied to the drum B. For the slowest speed the brake is shifted on to drum D. For the reverse motion the band brake is applied to the exterior of the clutch drum. Note in this article figs. 2, 3, 4, should read figs. 3, 4, 2. C. R. D'E.



962. *Clement Motor Bicycle.* **L. Fournier.** (Locomotion Automobile, 9. pp. 71–73, Jan. 30, 1902.)—In this machine a single cylinder petrol motor is attached to the bottom stay of the diamond frame, the cylinder being within the frame, with its head close up to the steering-post. The flywheel of the engine is mounted externally to the crank chamber at one side, and outside the flywheel is a grooved pulley round which passes a gut band, which transmits motion to the rear wheel of the machine. The driving band passes over a jockey pulley which is mounted on the seat-post. The carburettor is of the float-feed type. Electric ignition is employed. The motor develops 1 h.p. at 1,900 r.p.m. and weighs 7 kg. C. R. D'E.

REFERENCES.

963. *Crank and Connecting Rod Proportions.* **Loppé.** (Soc. Int. Elect., Bull. 1. pp. 555–556, Nov., 1901.)—A note on the ratio K of the tangential force on the crank pin of an engine to the force on the piston, with a table of values of K for different ratios of crank to connecting rod. B. P. S.

964. *Steam Engines for Driving Alternators.* (Soc. Int. Élect., Bull. 1. pp. 557–558, Nov., 1901.)—A schedule, communicated by the Sociéte d'Éclairage Électrique, of conditions which should be kept in view by designers of steam engines intended for the driving of alternators. The points specified to have reference mainly to the permissible range of cyclic variation of flywheel speed, the weight and speed of flywheel, alteration of speed while running by altering the governor weight, &c. B. P. S.

965. *Angular Velocity in Steam Engines.* **W. I. Slichter.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 767–779, Oct., 1901.)—Some calculations on variation of displacement, owing to variations of velocity within the cycle, of engines driving alternators. H. R. C.

966. *Angular Variation in Steam Engines.* **P. O. Keilholtz.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 729–766, Oct., 1901.)—Includes an account of some experiments in which actual variation of speed was measured by means of a tuning-fork trace on paper. H. R. C.

967. *Pumping Engines.* (Eng. Record, 44. pp. 474–477, Nov. 16, 1901.)—An account of the trials of four pumping engines built by the Holly Manufacturing Company. Three of these engines have a capacity of 35 million gallons a day, each, at a lift of 45 ft.; and the fourth has a capacity of 20 million gallons a day at a lift of 125 ft. At the trials the i.h.p. of each of the former was about 323 and that of the latter 464. The average steam consumption was about 11·1 lbs. per i.h.p.-hours. The paper gives full details of the trials. H. R. C.

968. *Transverse Stresses in Steam-pipes.* **A. S. Mann.** (Amer. Electn. 13. pp. 574–575, Dec., 1901.)—Considering the main steam-pipes as beams, the author examines the effect of the branch pipes in causing transverse stresses. H. R. C.

969. *Large Boiler Stoking Plant.* (Engineer, 92. pp. 584–585, Dec. 6, 1901.)—This article gives photographs and sectional drawings of complete coal and ash handling plant for a range of 16 Lancashire boilers, the total quantity of coal capable of being dealt with being 30 tons per hour. F. J. R.

970. *Chimneys.* (Eng. News, 46. pp. 466–468, Dec. 19, 1901.)—An account, with detailed drawings, of several recently constructed steel and steel-concrete chimneys in St. Louis, New York, Cincinnati, and Jersey. H. R. C.

GENERAL ELECTRICAL ENGINEERING.

971. *Electric Ship's Lift on the Dortmund-Ems Canal.* (Engineer, 93. pp. 6–8, Jan. 3, 1902.)—At Henrichenburg the level of the canal falls 50 ft., and vessels are raised or lowered at this point in a ship's lift, consisting of a tank 230 ft. by 28 ft. by 8 ft., capable of floating canal vessels up to 800 tons displacement. The work is done electrically by means of compound-wound-motors. W. H. S.

972. *Cassel's Self-regulating Water Wheel.* **E. C. de Segundo.** (Inst. Mech. Engin., Proc. 4. pp. 1013–1019; Discussion, pp. 1019–1024, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III.) 1901.)—The author describes in this paper the different atttempts which have been made to improve the water-motor so as to combine efficiency with economy and reliability in its action. After describing the different methods adopted in practice, the author thinks that the key-note to the solution of the problem was struck by the introduction of the deflecting nozzle. Moreover, he points out that satisfactory water-power governing can only be established in two operations—(1) The speed of the water-motor must be controlled without regard to the question of saving water; and (2) the apparatus for reducing the velocity of flow must then be brought into action. The author shows how the solution is worked out by E. F. Cassel. A detailed description of the construction of the wheel and the action of the governing mechanism is given in the paper, which is fully illustrated. From trials made by the author with an 18″ Cassel wheel driving a 5-h.p. dynamo it resulted that when the whole load was thrown on or off suddenly a variation of 1·7 per cent. to to 1·8 per cent. from the normal was perceptible, and the variation may be said to have been practically momentary. It was found that when the head was suddenly varied from 150 to 1,000 ft. the variation of speed did not exceed a momentary variation of 1·8 from normal. This method of construction lends itself to all known types of vertical impulse wheels, and the author concludes that the speed of the wheel can be relied upon to remain constant, irrespective of any variation in head or load.

Discussion.—**A. Barr** mentioned his device of governing by the aid of an adjustible nozzle in the case of low or moderate pressure. **J. Goodman** thought that a combination of Barr's nozzle with Cassel's motor would give good results, as a mere throttling device or a contracting nozzle could not be used successfully for the governing of water-motors. **M. Morrison** wrote inquiring whether larger wheels had been tried, and pointing out that in coupling electrical machinery to the water-wheel the moving parts of the wheel controlled by the governor had considerable inertia and friction, and one would expect a large turbine to take an appreciably greater time than the smaller ones to resume normal speed. He questioned whether the mechanical construction of the larger-sized wheels would not give trouble. The author, in reply to a question by **B. Donkin**, stated that he had never obtained a greater efficiency than 75 per cent., although 92 was claimed for it. He could see no reason why the Cassel wheel should not attain that efficiency. **J. Goodman** said that in testing Pelton wheels he obtained 80–88 per cent. The author said that he did not anticipate any difficulty in obtaining as close regulation in the larger size as he had obtained in the smaller ones. L. G.

GENERATORS, MOTORS, AND TRANSFORMERS.

973. *Modern Commutating Dynamo Machinery.* **H. M. Hobart.** (Inst. Elect. Engin., Journ. 31. pp. 170–217, Dec., 1901.)—The author considers that there should be more difference, in many features, between a 500 volt and a 100 volt machine for the same output and speed, than between two machines of the same voltage and very different outputs. He is satisfied that the magnitude of the reactance voltage per commutator segment is of the first importance in determining the performance of the machine from the commutating standpoint. It is of far more importance to have low reactance voltage per segment than to have low armature strength, as expressed in ampere-turns per pole. The author discusses the variations necessary in designing machines for a given output, but different voltages. He gives sketches, with tables of the principal dimensions and other data, for a line of four machines of 80, 100, 125, and 150 kw., each model being worked out for voltages of 115, 230, and 550. For the entire range of capacities, the cost of the net effective material varies but little from 16·3 shillings per kilowatt. The author discusses reactance voltage at considerable length, and gives a number of tables and curves showing the results of his experiments. He shows that the inductance of the "free length," that is the end connections, is 25 to 40 per cent. of the total; and with the ordinary open slots with parallel sides, the inductance per cm. of "embedded length," that is, the length in the slot, is only four to six times as great as the inductance per cm. of "free length." Hence the inductance of a coil on a smooth-core armature is rarely less than one-third, and often one-half as great as the same coil laid in a slot. With careful proportion in other respects, one may be sure of excellent results with reactance voltages not over 3 volts. On large slow-speed direct-connected machines the permissible limit for the reactance voltage increases considerably with the size of unit. For speeds of 80 to 100 r.p.m., 3 to 4 volts may be used with perfect success for the range from 400 to 800 kw. The author is unable to explain why the large sizes are less sensitive to high reactance voltages. Tables of data of his own designs for slow speed direct-connected units of 400, 1,000 and 1,600 kw. are given, and the practicability is discovered of obtaining good results as regards sparking in large dynamos for direct coupling to high-speed engines, he considers that it is purely a question of adopting sufficiently solid construction, to permit of an absolutely true running commutator at a high peripheral speed, both commutator and brush supports being completely free from vibration. He considers that one of the most characteristic novelties of his designs consists in the employment of fairly numerous poles combined with high armature strength per pole.

R. B. R.

974. *Design of Continuous-Current Dynamos.* **H. A. Mavor.** (Inst. Elect. Engin., Journ. 31. pp. 218–229; Discussion pp. 229–244, Dec., 1901.)—The author gives formulæ for calculating the total e.m.f., the reactance voltage, the average e.m.f. per section e, and the total ampere turns on the armature. He assumes that the ratio e/r has a very important bearing upon the commutating conditions of the machine, and gives formulæ and curves showing the relations between this ratio and the total ampere turns, the depth

of the slot, and the dimensions and speed. He considers that e/r should not be less than 1·6, and there is no advantage in going above 2. It has been assumed that the e.m.f. available for overcoming the reactance voltage may be taken as a definite proportion of the total e.m.f., and for this to hold true the ampere turns per pole should not exceed 10,000 per centimetre length of the air space. He suggests that there ought to be a regular relation between cost and output. This may be obtained by plotting watts per revolution as abscissæ and costs as ordinates. The position of each machine is marked, and the points representing cost and output for each carcase of given diameter and varying length are joined by a straight line, which is produced to cut the zero ordinate at a point which he calls the base cost of any given carcase. Its slope gives the cost per inch length of "active belt" on that carcase. Starting from the smallest diameter and passing to the largest will give a succession of straight lines enveloping a curve of which the tangents are the lines representing each machine, each tangent segment showing the economical range of length for the machine which it represents. A diagram is given to illustrate this. This method is useful up to 100 cm. diameter, beyond this the cost is very approximately proportional to d^2l.

Discussion.—**G. Kapp** gave a formula for calculating the output of a machine, $P = C\left(\frac{D}{100}\right)^2 L\left(\frac{U}{100}\right)$ where P is the output in kilowatts, D = diameter, L = length in cm. C is a constant, which is lower for a high-pressure machine, and also varies with the diameter, it may vary from about 0·6 to 2·6. An approximate formula is $C = 0{\cdot}6 + \frac{D}{200}$. But the formula is not accurate, because it does not take account of the pressure and heating limit, and for the same reason he was a little suspicious of the Mavor curve. **S. P. Thompson** considered it was only a rough approximation to take the ratio between reactance voltage and average voltage per bar of the commutator. The field for reversing during commutation is not the same as the average field under the pole, nor is it necessarily proportional to it. He discussed the problem of commutation. He considered the comparison of ampere-turns on pole and of the armature winding per pole to be fallacious. Given the density of flux, the speed and time of commutation, for a given type of machine there must be a definite number of amperes per inch of periphery of armature which can be commutated without a spark, which will be independent of the length of the machine and of the number of ampere-turns of excitation required. **W. A. Chamen** felt that the difficulty experienced with commutators in comparatively high-speed machines of large size is mechanical. **R. E. Crompton** mentioned the "Artillery Wheel Press" system of holding and compressing commutator segments into true cylindrical form. The machine consists of a large number of radial plungers worked by hydraulic means, forcing an iron ring inwards, so that the metal is actually upset. This machine has produced most excellent and permanently accurate commutators which give no trouble from subsequent displacement of segment. **W. B. Esson** said that in a former paper he had proposed to call the product of the number of conductors in the armature and the currents they carried the volume, and afterwards Thompson had suggested calling it circumflex. If the circumflex $V = 576lI/\phi$, the forward and cross induction under the pole tips would be equal, when I = induction in air-gap in c.g.s. units, l = length of air-gap, ϕ = angle of pole face in degrees. He recommended that the circumflex should not exceed half this critical value. He said that in Mr. Hobart's 1,600-kw. machine the circumflex was 348,480, whereas it should be 287,600, so that with 50 per cent. overload the field at the pole tips would be reversed. This shows that when the armature teeth are highly saturated the real air-gap is much more than the apparent air-gap. The magnetic resistance of the cross-field is probably 50 per cent. greater than the apparent air-gap and iron part would account for. **H. M. Hobart** said he found Mr. Mavor's formula for reactance voltage quicker than his own method. He did not pay much attention to shaping pole corners, and considered it was only successful in exceptional cases. With regard to Mr. Esson's remarks he thought that machines might be run with much higher armature strength, provided the reactance voltage was low. **H. A. Mavor** said his formula enabled the designer to calculate reactance voltage without considering any extraneous matters, the value being obtained directly from the watts generated by the machine, its diameter, turns per section on the armature, and average field. R. B. R.

975. *Armature Reaction and Alternator Design.* **J. Fischer-Hinnen.** (Zeitschr. Elektrotechn., Wien, 20. pp. 29–33, Jan. 19, and pp. 41–46, Jan. 26, 1902.)—After briefly referring to the methods proposed by Behn-Eschenburg, Rothert and Potier [see Abstract No. 566 (1902)], for pre-determining the voltage-drop in alternators, the author sketches out his own method. Let $X =$ field ampere-turns ; $f(X) =$ corresponding e.m.f. ; $\alpha =$ angle of lag of current behind e.m.f. ; $x =$ armature ampere-turns. Referring to Fig. 1, the author splits up the armature ampere-turns into two components, $x \sin \alpha$ and $x \cos \alpha$; the former, which corresponds to the back-turns, is to be subtracted from X ; the latter gives the cross-turns. From the open-circuit characteristic we can find the e.m.f.s $f(X - x \sin \alpha)$ and $f(x \cos \alpha)$ corresponding to the ampere-turns $X - x \sin \alpha$ and $x \cos \alpha$ respectively. Since, however, x is small, so that $f(x \cos \alpha)$ lies on the straight-line portion of the characteristic, we may write $f(x) \cos \alpha$ for $f(x \cos \alpha)$. The e.m.f. diagram is shown in Fig. 2, ϕ being the angle of phase-difference between the terminal p.d. V and the current I ($\cos \phi =$ power-factor of load). V may be regarded as the resultant of rI (armature resistance drop), the e.m.f.s $f(X - x \sin \alpha)$ and $f(x) . \cos \alpha$, and y, which corresponds to the leakage induction e.m.f. of the armature. By producing BA and CD until they intersect in E, it is easy to see that $DE = f(x)$, and $AE = f(x) \sin \alpha$. Hence, neglecting rI, which is always small, the diagram may be simplified as shown in Fig. 3. The angle α is, however, unknown in the first instance ; it is generally $> \phi$, and as a first approximation

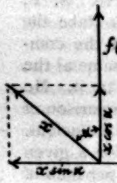


FIG. 1.

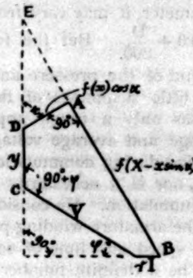


FIG. 2.

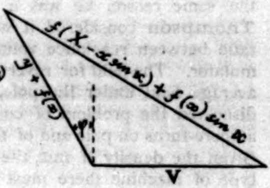


FIG. 3

we may put $\alpha = \phi$. The author gives a table of values connecting $\cos\phi$ with $\cos\alpha$. In the special case $\cos\phi = 0$, the p.d. is obtained by subtracting y from $f(X - x)$. Hence, assuming that the open-circuit characteristic (Fig. 4), x and y are given, it is a very simple problem to find the connection between the field ampere-turns and the p.d. for a given value of wattless armature current. The corresponding curve is shown dotted in Fig. 4, and is readily seen to be the open-circuit characteristic displaced through a distance $z = \sqrt{x^2 + y^2}$ in a certain direction. This result had been pointed out by Potier, but the author utilises it for determining the values of x and y. Assuming that the following data are known: (1) the open-circuit characteristic; (2) one value V of the p.d. corresponding to a wattless current I; (3) the field ampere-turns A necessary to produce the short-circuit current I; the values of x and y corresponding to the current I may be found thus: Draw the rising portion of the open-circuit characteristic on a piece of tracing-paper, and then slide it along AV parallel to itself until A coincides with V. If through the points V and B two lines be drawn parallel to the co-ordinate axes, then the sides of the triangle so formed give the values of x and y for the current I.—The second part of the paper deals with the determination of the dimensions of an alternator for a given maximum voltage drop. A. H.

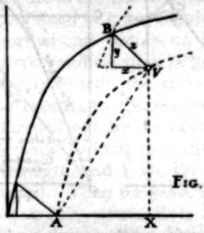


FIG. 4.

976. *Sparkless Commutation with Fixed Brushes.* **C. W. Hill.** (Elect. Rev. 50. pp. 44–47, Jan. 10, 1902.)—The author gives diagrams showing the resultant field with one, two, and three coils short-circuited by the brush, showing that the resultant field is less as more coils are short-circuited by the brush. He also gives formulæ for calculating the resistance voltage in a coil short-circuited by the brush. R. B. R.

977. 1,000-*kw. Tramway Generator.* **Niethammer.** (Elektrotechn. Zeitschr. 23. pp. 45–46, Jan. 16, 1902.)—This is a description of a machine built for the Sheffield Corporation by the Union Elektrizitäts Gesellschaft of Berlin. The machine gives 1,000 kw. at 500–525 volts, 90 r.p.m., with an efficiency at full load of 94·4 per cent., at ¾ load 93½ per cent., and at ½ load 92½ per cent. It has sixteen poles, and the armature diameter is 3·5 metres.
A. E. L.

978. *Best Degree of Saturation in Polyphase Generators.* **E. Korrodi.** (Elektrotechn. Zeitschr. 23. p. 47, Jan. 16, 1902.)—In the figures below, *o f b* and *o g b* represent the voltage-excitation curves of two machines with similar armatures, but with the fields working at low and at high density respectively. Fig. 1 is a comparison of the loads required to produce the same drop of voltage in both machines. Here *e a* represents the reactive ampere-turns—the same in both machines; ef_1, the self-induction of machine 11 and ef_2, that of machine 2. Then *a b* represents the drop in voltage common to both machines, while the loads required to produce this drop will be as af_2 is to *a g*. Fig. 2 is a comparison of the excitation required at the same load, *a e*, ef_1, ef_2, and *a b* having the same meaning as before, while $f_2 g$ is drawn parallel to the axis of *x* to cut the curve *o g b*, and *g a*, is parallel to af_2. Then the excitation required for Machines 1 and 2 respectively will be represented by *c a*, ca_1. While an increase in the density of the fields improves the regulation up to a certain point, a further increase, by increasing the self-induction of the armature, brings f_2 above the curve *o g b*, so that the regulation is worse than that of Machine 1. A. E. L.

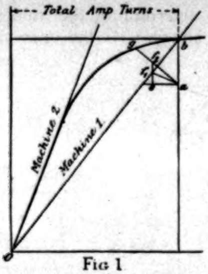


Fig 1

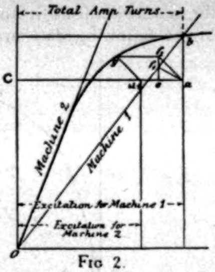


Fig 2.

979. *Motor Starting Devices.* **H. C. Heidrich.** (Elect. Rev. N.Y. 40. p. 5, Jan. 4, 1902.)—When current is cut off from a motor by a fuse blowing in the central station the fuse may be replaced before the release magnet of the starting resistance has let go of the arm and put in the resistance. This may lead to damage of the armature if the speed of the motor has fallen low. The sluggish action of the release magnet is due to the shunt motor maintaining its field by generator action, and the author proposes to quicken the action by connecting in the main circuit a relay which, when no current passes, short-circuits the release magnet. G. H. B.

980. *Sychroniser for Three-Phasers.* (Schweizerische Blätter für Elektrotechnik, 7. pp. 10–12, Jan. 22, 1902.)—This paper contains an illustrated description of the synchronising device manufactured by the E. A. G., consisting of a synchronising transformer whose secondaries are divided up into sections connected to a number of incandescent lamps arranged in a circle. The primaries are on one side connected to the 'bus-bars, and on the other to the terminals of the incoming machine, the connections being similar to those used in the Siemens and Halske synchroniser. [See Abstract No. 892 (1899).] The lamp connections are such that the intensity varies from zero to a maximum in a quadrant, there being two diametrically opposite maxima of brightness. The two crescents of light thus formed revolve until synchronism is reached, when they become stationary; the co-phasal relation corresponding to a definite position of the crescents. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

981. *Surges in Transmission Circuits.* **A. E. Kennelly.** (Elect. World and Engineer, 38. pp. 847–849, Nov. 23, 1901.)—Referring to Steinmetz's article on this subject [see Abstract No. 411 (1902)], the author points out that many of the results contained in it are capable of a very simple general explanation. When a short circuit occurs on a transmission line, and is interrupted at a phase corresponding to a large value of the current, the electromagnetic energy associated with the circuit takes the form of electrostatic energy, which again returns to the electro-magnetic form, and so on, until the oscillations are damped out by the resistance of the circuit. Let l and c stand for the inductance and capacity respectively per unit length of the circuit, L for the total length, and I for the value of the current at the instant of opening the circuit. Then we have, neglecting the damping due to resistance, $\frac{1}{2}\,\mathrm{L}\,l\,\mathrm{I}^2 = \frac{1}{2}\,\mathrm{L}\,c\,\mathrm{E}^2$, where E is the maximum value of the e.m.f. induced on rupturing the circuit. Hence $\mathrm{E} = \mathrm{I}\sqrt{l/c}$, from which it appears that the maximum induced e.m.f. is (to a first approximation) independent of the length of the circuit. In the case of overhead lines, l is relatively large and c is small, so that dangerous rises of potential are more likely to occur than on underground cables, for which l is small and c large. As rough average numerical values, the author gives 600 volts per ampere of suddenly interrupted current for overhead wires, and 40 volts per ampere for underground wires, corresponding to the first surge of e.m.f., before appreciable damping has taken place. The frequency of these free surges is such as to make $\mathrm{L}\,l\,p = 1/\mathrm{L}\,c\,p$, where $p = 2\pi \times$ frequency, and since $1/\sqrt{ol}$ is the velocity with which the electromagnetic waves run through the dielectric, p is numerically equal to the number of journeys that these waves can make in running to and fro along the circuit in one second. For practical purposes the limiting frequency of free surges may be taken as 30,000/L periods per second, when L is expressed in miles. The author points out that such free surges must be carefully distinguished from the stationary waves of p.d. and current in long transmission lines due to *forced oscillations* depending on the frequency of the generator, and produced by resonance effects. A. H.

982. *The Relative Advantages of Three-, Two-, and Single-phase Systems for Feeding Low-tension Networks.* **M. B. Field.** (Inst. Elect. Engin., Journ. 31. pp. 138–158; Discussion, pp. 159–169, Dec. 1901.)—For tramway work alternating motors are at present impracticable; the necessity of efficient speed regulation with large starting torque, and the inadvisability of having more than a single rolling or sliding contact to bring the current into the car, make the direct-current series-motor the only possible one. At the same time, in cases where power has to be transmitted from a single central station to a number of remote feeding centres, high-tension alternating currents may be essential for the transmission. Suitable converters must be placed at the feeding centres for transforming to continuous current at 500 volts. These may be either (1) rotary converters combined with static transformers; (2) synchronous motor generators; (3) non-syn-

chronous motor generators. With rotary converters, the output when used as a D. C. generator being taken as unity, will be 0·825, 1·31, 1·61, and 1·94 when used as a single-, three-, four-, or six-phase rotary respectively. A table is given showing various data of construction and performance (heating, efficiency power factor, starting current, &c.) of rotary converters and motor generators of the two types; and another table with prices, weights, and efficiencies of converter equipments based on estimates given by three or four leading makers. Three- and two-phase rotaries with transformers, three-, two-, and single-phase synchronous motor generators, and three-, two-, and single-phase induction motor generators are the types of plant of which data are given; the single-phase rotary is not included, working, as it does, at such disadvantage compared with the two- and three-phase rotaries. The author gives the preference, all things considered, to the two- or three-phase rotary with transformers as being no more complicated than the motor-generator, and as being, in his experience, unexceptional from the point of view of overload capacity, ease of regulation and manipulation. It is possible, but not easy, to make a well-designed machine of this kind surge. *Cables.*—An exhaustive comparison follows of various cable systems, taking as a basis one mile of three-core cable with earthed neutral, transmitting 1,000 kw. at 6,500 volts, three-phase, the area of each core being 0·15 sq. in. The results are tabulated, the table showing the strains on the insulation of the cables and of the machinery (not necessarily the same thing), the areas of cables for a given loss per mile (6·3 kw.) when transmitting the same power, and cost per mile laid and jointed, including laying of ducts (iron, cement-lined, Glasgow practice), and drawing in. The advantage in point of price is seen to be clearly with the three-phase, three-core system with earthed neutral point, but the author personally prefers an unearthed system, a proper check being kept on the insulation. Board of Trade requirements may entirely modify the results given in the table. Examples are given to illustrate this point. As regards *switchboards*, the simplification effected by employing a single-phase circuit is more apparent than real. In Glasgow the whole value of the switchboards was only one-fifth of that of the whole cable system, so that the saving under this head, which might have been effected by a single-phase system, would have been negligible. *Generators.*—The author obtained prices from different makers for three-phase and single-phase generators, 2,500 kw. at 6,500 volts, 75 r.p.m. and 25 periods, drop at full load (power-factor unity) not more than 7 per cent. The results (weight and cost) are tabulated. The mean figures are—three-phase, weight 111 tons, cost £5,340; single-phase, weight 138 tons, cost £6,595, or an increase in both weight and price of about 23 per cent. for the single-phase as compared with the three-phase machine. Where lighting and power-work are combined, there is, in the author's opinion, something to be said for single-phase. For a three-phase distribution really shows no advantage over distribution by single phase, as any theoretical advantage held by the former is compensated by the fact that the single-phase distribution would, in practice, be by the three-wire system, which would not be feasible in the case of three-phase, owing to the difficulty involved in the independent regulation of the circuits. A three-phase system is alluded to which has been adopted with some success in America and elsewhere, in which to avoid regulation in substations the voltage of one phase alone is kept constant at the generating station, all the incandescent lights of the system being connected across this one phase; the other phases are left to look after themselves. No attempt is made to balance the loads on the three phases; but the effect of motors and transformers is to equilibrate the different loads, the lightly-loaded motors acting to some extent as generators and supplying current to those which are more heavily loaded. In a note the author gives his idea of the lines on which the problem of the employment of three-phase motors for tramway work in crowded cities will be solved—by the combination, namely, of two shallow conduits of the slot-rail type, with surface contacts laid every 2 or 3 ft. Every fortieth contact would control the succeeding thirty-nine, which would be of the simplest character, with no mechanism whatever. Other notes are: a table of power-factors, at full and half-load, for single- and three-phase motors of different sizes, and a table of readings of pressure and current in a test made on a three-phase generator loaded on a three-phase motor, two of the phases being loaded on a non-inductive resistance as well, showing the balancing effect on the three phases of the non-inductive load.

Discussion.—**Kolben** agreed that for metropolitan areas the right thing at present is combined three-phase and continuous-current distribution. The serious objection to the three-phase motor is the question of speed-regulation, which entails larger generating plants and stations than would otherwise be necessary, owing to loss of energy in regulating. This was the case also with direct-current motor systems, until the invention of the series-parallel controller. Apart from the question of economy of running, it is cheaper to instal three-phase generators, with substation converters and continuous-current motors, than to make a three-phase generating station large enough to supply the margin of power required in the speed regulation of three-phase motors. As regards the pressure regulation of a three-phase supply, a difference of even 30 per cent. in the load on the different phases makes a very small percentage difference of pressure between the phases. **H. S. Carhart** thought that a frequency of not much more than 25 would be sufficient for incandescent lighting, and something rather higher than this again for arc lighting; it need not be so high as 50. Open-type arcs are rapidly disappearing in the United States and giving way to enclosed lamps, which can be run in series on a three-phase distribution. In the transitional stage three-phase or synchronous motors are used to furnish power to run the direct high-tension generators for the open-type arcs. **W. B. Esson** observed that three-phase distribution does for alternating current exactly what the three-wire system did for direct current, as regards weight of copper. In future there will be no more single-phase stations; they will be either three-phase or direct current, or (in the case of conversion from single-phase stations) two-phase, for the reason that it is easier to adapt existing systems of mains to two- than to three-phase working. **S. P. Thompson** considered the complication usually considered to attach to three-phase switchboards of connections to be quite imaginary. **Blathy** thought that where accumulators are to be charged motor generators are preferable to rotaries. The best way, however, to run tramways or railways is to drive the motors direct with polyphase currents. The experiments now being carried out on the railway lately built in Italy, until now run by steam, but in future to be actuated by polyphase current (the first of its kind), have proved perfectly satisfactory up to the present. Passenger traffic is to be run at 40 miles an hour, goods traffic at 20. Trains will be run at least as heavy as those formerly drawn by steam locomotives, and probably considerably heavier. The stations are about three miles apart. As to the general question of electric traction, an advantage over the steam locomotive was that the weight of the tender—about 30 tons on the average—is dispensed with, and the torque on the driving wheels is absolutely uniform, instead of varying as between 2 and 3, as in the case of the steam locomotive, where the adhesive weight consequently has to be sufficient to take the maximum. In the electric locomotive the total adhesive weight is available at every instant for utilising the work of the motors. As regards frequency, the standard has been gradually going down to 42, at which it now stands. Most new stations erected on the Continent have this frequency. **G. Storey** alluded to the advantages of synchronous motors in reducing the lag due to induction motors; but the author thought this an expensive method of attaining the result desired. **W. Geipel** pointed out that with a three-phase lighting system it is possible to use lower voltage lamps, while obtaining the economy of the higher voltage for motors. B. P. S.

983. *Production of Electrical Energy from Carbon.* **W. R. Cooper.** (Feilden, 6. pp. 9–15, Jan., 1902.)—In this paper the author first discusses the saving which is likely to be obtained by the substitution, in generating stations, of the boilers, steam-engines, and dynamos by electrolytic cells consuming carbon directly, *e.g.*, in the form of coke, and having an efficiency of 70–75 per cent. Taking—

Costs of generation	Fuel	1d.	
	Other items	2d.	3d.
Capital charges ...	Generating station	1·3d.	
	Mains	1·1d.	2·4d.
			5·4 pence per unit sold,

and assuming that only $\frac{1}{12}$th of the amount of fuel at present required were used a saving of 17 per cent. would be effected; and assuming the cost of buildings and battery to be $\frac{1}{3}$rd less than that of a steam plant, a further saving of 7 per cent. would be obtained, giving a total probable saving of 1·3d., or 24 per cent. The action of carbon-consuming cells is then discussed, and the Jacques and Blumenberg cells are described. C. K. F.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

984. *Electric Power at Ikervar, in Hungary.* (Soc. Belge, Élect., Bull. 18. pp. 383–397, Nov., 1901.)—In this article a detailed description is given of the hydraulic plant and electrical installation at Ikervar, in Hungary. The power is transmitted to Szombathely and Sopron, and is used for lighting the surrounding villages, for working two lines of tramways, and for other industrial purposes. The water power is derived from the river Raab, a tributary stream of the Danube; the flow of water is about 22 cubic ft. per second, and the total available power is over 2,000 h.p. The power-house is situated about 3 km. from the towns of Ikervar and Sarvar. Five Jonval turbines are erected, of which each is capable of developing about 300 h.p. at 160 r.p.m. Each turbine has coupled direct to its horizontal shaft two 6-polar direct-current Thury dynamos, the high e.m.f. required being obtained by coupling a number of series-wound generators in series on the Thury system. [See Abstract No. 1369 (1900).] The turbines are manufactured by Messrs. Escher-Wyss, of Zürich. The generating plant at Ikervar is divided into two distinct groups. The group A contains three turbines, each driving two dynamos of 97·5 kw. capacity at 1,500 volts, or a total voltage of 9,000. The Szombathely circuit is connected on to this group. The other group, B, contains two turbines, each driving two dynamos of 100 kilowatts capacity at 2,500 volts, giving a total voltage of 10,000. The Sopron circuit is provided with power from this group. At Ikervar each dynamo has its independent switchboard, and as the demand for power increases or decreases, so the number of dynamos are put on the circuit or cut out by a simple device. The power is transmitted to several substations, where motor-generators are used, so as to provide current either at 150 volts for lighting purposes or at 550 volts for the tramway working or other motive power. On the high-tension lines from Ikervar to Szombathely and Ikervar to Sopron there are a few installations connected, where the motors are put in series, and used for agricultural purposes: ploughing, threshing, tilling, grinding, &c. One of these installations consists of thirty motors, each of 10 to 20 h.p., coupled in series, and they work very satisfactorily. The speed of the motors is kept regular by suitable governors invented by Thury.

The Szombathely high-tension line is about 65 kilometres long, and the total loss in transmission and transformation is 27·5 per cent. The sectional area of the conductors is 70 sq. mm. A telephonic line is fixed, a metre lower than the high-pressure line, on the same posts on which the conductors are carried. The Szombathely substation contains two 130-h.p. motors, each driving two 75-kw. dynamos; another motor of 110 h.p. drives two 74-kw. dynamos. A 50-h.p. motor drives a dynamo of 33 kw. at a voltage of 550 for the tramway line. An accumulator battery of 120 Tudor elements, with a capacity of 540 ampere-hours, is also erected there. As reserve a large steam boiler is put up, which can, in case of emergency, work a 200-h.p. vertical compound engine. The three-wire system is used in the lighting circuit. There are about 8,000 lamps connected. The tramway line is 2,700 m. long; the overhead wire system is applied. The Szombathely circuit provides the current for the lighting of about twenty villages, the most important being Ikervar and Sarvar, which have their own substations. The Szombathely railway station has a 130-h.p. motor, driving two dynamos of 35 kw. output for the lighting of the station.

The Sopron line is about 150 km. long, and the sectional area of the conductors is 80 sq. mm. About thirty villages are supplied from this circuit. The transmission and transformation loss is 27 per cent., the drop per km. being 8 volts. The substation at Soprano contains two motors, driving each two 40-kw. dynamos at 150 volts, and an accumulator battery. A 130-h.p. gas engine has been erected as a reserve. For the tramway circuit there is a motor driving two 41-kw. dynamos, and a battery of 275 Tudor elements is provided. The tramway (a trolley line) is 5,200 m. long. L. G.

985. *Roux Electric Generating Station.* **L. Gerard.** (Soc. Belge. Élect., Bull. 18. pp. 417–434, Dec., 1901.)—Electric energy is distributed from this station to the district of Charleroi, by three-phase high-tension currents, transformed on the consumers' premises to a pressure suitable to the nature of the service required. Details of the foundations, which were of a special nature owing to the character of the site, are fully described. Dimensions and details of the construction of the engines are also given. These are of the compound tandem condensing type by Van den Kerchove, with equilibrium valves of a new and ingenious design by M. Vanderstegen. The steam pressure employed is 135 lbs. per sq. in. With a load factor on the machines of only 18 per cent., the consumption of coal per kw.-hour is about 7 lbs. The engine governors are of special construction designed to permit of parallel

running of the direct-coupled alternators. The three-phase alternators are by Brown and Boveri, of Baden, and are designed for an output of 250 kw. at 6,000 volts, 40 periods, when running at a speed of 400 r.p.m. At this output the efficiency is 92·8 per cent. The exciters are mounted on the same shaft as the alternators, and are each large enough to furnish exciting current to two alternators. In designing the station special means have been taken to avoid crossing of high-tension conductors, and also to permit of the electrician in charge to see the switchboard and machinery at a glance. The means adopted are fully described. The switchboard is of unique construction. It is in pulpit form, the switch handles and regulators being fixed on a nearly flat marble board and the instruments on a vertical board of glass in front of the switches. By this means the attendant can have his hands on the regulators, see the instruments on the glass board in front of him, and the machine hall beyond, all at the same time. The district served by this station embraces the Communities of Seneffe, Godarville, Pont-a-Celles, Gouy, Trazegnies, Roux, forming a total of 28,100 inhabitants. The primary cables have a length of about 32 km., and the secondaries 89 km. A map of the district, showing the routes of the cables, is given. The supply voltage is 220 volts single-phase for lighting, 600 volts three-phase for motors over 5 h.p., and 220 volts three-phase for motors below this power. F. B.

986. *Brooklyn Electric Station.* (Power, N.Y. 21. pp. 1–5, Dec. 1901.)—The station was originally designed to receive four 3,000-h.p. double horizontal tandem alternating-current sets and two smaller sets, making in all 14,000 h.p. The engine-room floor-space allowed was 13,600 sq. ft., or about 1¼ sq. ft. per kw. The floor-space actually taken by the first two horizontal 3,000-h.p. sets was 0·415 sq. ft. per h.p., or 0·623 per kw. The first extension consisted of two 4,500-h.p. Westinghouse *vertical* sets, the saving in space being very great. The actual space occupied is 0·27 sq. ft. per h.p., or 0·427 per kw. Had vertical engines been used throughout, it would have been possible to install 5 units of 4,500 h.p., or a total of 22,500 h.p., in the space intended for 14,000 h.p. This shows the difference in American practice in 1897 and 1901. Details of the engines are given. The maximum pressures on the cross-head and crank-pins are 1,200 and 1,000 lbs. per sq. in. respectively, and on the main bearings 250 lbs. With a steam pressure of 165 lbs. per sq. in. and a vacuum of 26 in., the guaranteed steam consumption is 15 lbs. per i.h.p. at ¾ load. [A full description of the engines is given in *Power*, March, 1901.]

The condensing plant and piping is so arranged that the condensers and air pumps are interchangeable, and may be used in connection with either engine, or with either side of each engine in the event of one side being run as a simple condensing engine. The automatic valves for atmospheric exhaust are provided with air cushions. The lubrication of all bearings is effected by means of a pneumatic oiling system, pressure for which is furnished by a direct driven air compressor, which also supplies compressed air for cleaning boiler tubes and armatures, and other work. The coal- and ash-handling plant is very complete, and is described. The system of generation is three-phase alternating at 6,600 volts. Plan and elevation of the station are given, showing the plant and piping arrangements. F. B.

987. *Maidstone Electricity Works.* (Elect. Engin. 29. pp. 6–10, Jan. 3, 1902.)—The three-wire continuous-current system is employed; 230 volts each side. The steam generating plant consists of four Davey, Paxman & Co.

multitubular boilers, each capable of evaporating 6,000 lbs. of water per hour. Working pressure 160 lbs. per sq. in. The main steam pipes are in duplicate, but all valves are in the branch pipes. The feed-pumps and pipes are in duplicate. The surface condensing plant can deal with 18,000 lbs. of steam per hour. The electric generating plant comprises four 150-kw. and one 75-kw. dynamos, each coupled to a "Peache" engine, the larger sets running at 375 r.p.m., and the smaller at 420 r.p.m. The balancing and charging is done by a combined balancer and booster, consisting of four machines coupled together, the two outer ones being the boosters. The shunt regulating switches for all machines are fixed in a polished teak rail in front of the switchboard, the latter being of Messrs. Kelvin and White's make. A set of 280 chloride cells in glass boxes forms the battery, which has an output of 100 amperes for five hours, or 300 amperes for one hour. The distribution is on the Callender solid system, by the three-core pilot-cable; the arc-lighting mains, and the services to the consumers are armoured with steel tape and laid direct in the ground. The feeders, of which there are six, contain only two conductors, and two neutral feeders are laid. Mains are laid in 5 miles of streets. Sizes and details are given. The load is equivalent to over 9,000 8-c.p. lamps. Details of the chimney and of the foundations, which are of a special nature, are also given. F. B.

988. *Crystal Palace District Electricity Works.* (Electrician, 48. pp. 449–452, Jan. 10, 1902.)—After the boiler explosion in July, 1900, the works were shut down for some time, and various alterations were made. The article describes the present state of the station. The engine-room is 79 ft. by 82 ft. 6 in., and the boiler-house is 57 ft. long by 30 ft. wide. The chimney is 110 ft. high, the internal measurement being 6 ft. square. The three boilers are by Hornsby, each being of 276 nominal h.p. The 9-in. steam main is arranged on the ring principle. The generating plant includes three 210-kw. sets, and two of 90 kw., and one of 45 kw., giving their outputs in direct current at 1,000 volts. There are ten substations in all, at six of which batteries are installed which have a total maximum discharge rate of 180 kw.; the remaining four substations are worked on the Oxford system, and switched in from the works by means of three-core pilot wires. The largest substation is at the Crystal Palace, and contains four 70-kw., three 40-kw., and two 66-kw. fixed ratio E.C.C. transformers in addition to a battery. The high-tension feeders vary from 0·25 sq. in. to 0·06 sq. in. in sectional area. W. H. S.

989. *Lighting System of the Chicago Edison Company.* (Elect. Rev. N.Y. 40. pp. 42–52, Jan. 11, 1902.)—In this system, a track of country extending 26 miles N. to S. by 10 miles at its widest part is supplied with current. The city limits are supplied with direct current from underground mains, outside this the supply is alternating current at 60 cycles. This network is supplied from a number of stations and substations, of which the Harrison Street Station is one of the most important. Here the boilers are of the Heine water-tube type, 7 of 500 h.p. and 17 of 570 h.p., with Babcock and Wilcox automatic stoking chain grates directly supplied with Illinois screenings through chutes from overhead storage-bins, to which the coal is taken by conveyors from boats or railway trucks. There are four steel smoke-stacks each 180 ft. high by 12 ft. in diameter. The generating plant comprises two double-current and two direct-current units, each consisting of two 200-kw. generators, coupled to the two ends of a Southwark triple-expansion, vertical marine-type engine running at 150 r.p.m. These double-current machines give 150 volts on the direct-current side, and three-phase alternating current on the other side. There are also six 1,200-h.p. sets generating direct current; a 2,500-kw. double-current generator, capable of working up to 3,200 kw. for three hours, giving 300 volts on the direct-current side, and six-phase, 25-cycle current on the alternating-current side at 75 r.p.m. This is mounted at the middle of the crank-shaft of an Allis vertical cross-compound engine of a maximum output of 5,000 h.p. The armature is 21 ft. 8 in. diameter, the commutator 15 ft. diameter with 960 bars and 560 brushes; there are 40 poles. A 3,500-kw. alternator is being erected, which will give three-phase current at 9,000 volts, and a frequency of 25, which is to be the standard for the system. There are also transformers to step up the current for transmission to outlying substations. The capacity of the station is at present 17,800 kw., the ultimate capacity is to be 27,000 kw. Outside the central direct-current service, distribution is by means of an alternating current at a frequency of 60 on a four-wire three-phase system, having a maximum of 2,400 volts between the neutral point and any one of the outside terminals. At the Lake View Station, 9,000-volt, 25-cycle, three-phase current is received from the Harrison Street Station and transformed by motor-generators to three-phase, 60-cycle alternating current at 2,400 volts between the neutral or fourth wire and any outside terminal. This station supplies current at 5,000 volts and 60 cycles to the Edgewater Station 4 miles away.

The distribution to the western district is on the three-phase four-wire system. The southern district of about 65 square miles is supplied from a station in 56th Street on the three-phase four-wire system [see Abstract No. 579 (1902)]. An example of the direct-current supply substations is the Dearborn Street, in which there are three 500-kw. 8-pole rotary converters, receiving six-phase alternating current, and feeding direct current into the outsides of the three-wire, low-tension, direct-current network. There are also 9 transformers receiving 9,000-volt current from the Harrison Street Station, and feeding six-phase current at the required voltage and phase. In the Adams Street substation there is a 22,400 ampere-hour (at 8-hour rate) storage battery of the chloride type, with a maximum current of 11,000 amperes for 1¼ hours. Each cell has 87 plates (15¼ in. by 32 in.), and weighs 6,200 lbs. The field regulation of the charging dynamos at Harrison Street is governed by rheostats, controlled by small motors worked from the switch-board of the Adams Street Station. The total light and power load was equivalent, in September, 1901, to 1,100,000 16-c.p. lamps, of which 69·2 per cent. was for lighting, and 30·8 per cent. for power. The Wright maximum demand system is used. The capital is six million dollars. C. K. F.

990. *Central Station of the Syracuse Lighting Company.* (Elect. Rev. N.Y. 40. pp. 109–112, Jan. 25, 1902.)—The station stands upon the bank of the Erie Canal, about half a mile from the centre of distribution for light and power, and is so situated that it has also convenient delivery for coal by railway as well as unusual facilities for the reception of fuel from boats on the canal. The motive-power equipment is entirely of the steam-operated type. The boiler-room contains eighteen return tubular boilers set in brick, each 6 ft. in diameter by 17 ft. long. Hand firing is used. The water is pre-heated and filtered. The steam-driven units consist of three McIntosh and Seymour vertical compound engines, two of these units being coupled directly with 600 kw. three-phase, 60-cycle, 2,400-volt alternators of the general electric type,

and one of them to a single-phase alternator of the same capacity and frequency. In addition to these units there is a McIntosh & Seymour horizontal cross-compound engine of 1,500 h.p. direct-coupled with an 850-kw. direct-current generator and two engines of the Allis type, one of 500 h.p. and one of 1,000 h.p., belted through a countershaft to a group of arc generators. Two exciters, each of 50 kw. capacity, are direct-coupled to synchronous motors, and there is also a 200-kw. and 500-volt rotary converter. No less than 1,800 h.p. is required for motors, which are mostly operated on the 500-volt direct-current circuit. Lighting is accomplished from the different phases of the three-phase supply, operated at 2,300 volts from the station, and the current appropriately transformed by means of transformers. Arc lighting is effected by means of direct-current apparatus. For generating the direct-current for this purpose, there are installed twenty-three 50-light General Electric machines, and two Brush 125-light arc machines. For street illumination 1,350 series arc lamps of nominal 2,000 c.p. are in use. Connected with the company's general distribution system are the equivalent of 95,000 16-c.p. incandescent lamps. The article is well illustrated with photographic views, showing different parts of the works and installation. J. L. F. V

991. *Newcastle-upon-Tyne Electric Tramways.* (Tram. Rly. World, 11. pp. 1–12, Jan., 1902.)—Details of special foundations due to the nature of the ground, and special building work due to the bricklayers' strike are first given. The total length of route is 16¼ miles of double track, the maximum gradient 1 in 13½, and the sharpest curve has a radius of 40 ft. The rails are in lengths of 45 to 60 ft., and are of steel, having not less than ½ per cent. of carbon. They are 7 in. high and 7 in. wide in the base, and 2 in. broad in the head. The fish-plates weigh 73 lbs. per pair. The rails are laid on a concrete bed extending 18 in. outside the tracks, and are held together by steel tie-bars 2 in. by ⅜ in. In many places the streets have been re-paved from kerb to kerb, principally with Jarrah wood blocks, but in some places by granite setts 6 in. deep. The whole construction of the road and track is very substantial, and cost £18,000 per double-track mile. The feeder ducts, which are of fire-clay or cement, are laid under the road bed between the tracks. The manholes are 400 ft. apart. The rails are bonded with 8 in. flexible bonds, equal in section to 0000 B and S, and are cross-bonded with a wire of the same section at distances of 90 to 135 feet. The poles for the overhead equipment are spaced 120 ft. apart, and vary in height from 27 ft. 9 in. to 31 ft.; and in diameter from 6 in. to 9 in. at the base, and from 4 in. to 5¼ in. at the top. The first equipment of cars includes 60 of the single-deck bogie type with 8 wheels, 20 single-deck cars on four-wheeled trucks, and 65 double-deck cars on four-wheeled trucks. The wheel base of the single-truck cars is 6 ft., and of the double-truck 15 ft. In the power-house three main generating sets are at present installed, of which the engines are of the vertical inverted type. The largest is a triple expansion engine of 2,000 i.h.p., running at 90 r.p.m., with a steam pressure of 165 lbs. per sq. in. The other two engines are of 1,000 i.h.p., each running at 90 r.p.m. The air-pumps for the condensers are worked from the high-pressure cross-head in the case of the large engine, and from the low pressure one in the case of the smaller sets. Condensing water is obtained from the River Tyne, a quarter of a mile from the generating station. In a pumping-station on the quay two large centrifugal pumps force the water through a 24-in. pipe to the power station, against a head of 90 ft. After passing through to the condensers, the water falls by gravity through

another 24-in. pipe to the pumping station, where it is used to drive two turbines mounted on the same spindles as the pumps. Two electric motors supply the power required, in addition to that developed by the turbines. The large electric generator has 12 poles, and is rated at 1,800 kw., and can give 50 per cent. overload. The two smaller machines are of the 10-pole pattern, each rated at 650 kw. The combined efficiency is 85 per cent. The current is direct at 500–550 volts. Coal is delivered by means of a railway siding, carried on a lofty steel viaduct, into the top of the building directly above the firing floor, where the coal is discharged into overhead bunkers, and is then fed by gravity, through automatic weighers, into the mechanical stokers. Good photographs of the track during construction, of the power station, and of the cars are given, also a sectional elevation of the power station, sections of the rails and bonds, and a plan of the district served by tramway system. F. B.

992. *The Metropolitan Electric Railway, Paris.* **Détroyat.** (Soc. Int. Élect., Bull. 2. pp. 186–155; Disscussion, p. 155, Feb., 1902.)—The service is one of 550 volts continuous; the current is picked up by cast-iron slides running on an insulated third rail of hard steel, to which the current is brought by cables (bare or insulated) from the feeding centres. The lighting is by series of five 110-volt lamps. Special means are provided by duplicating circuits, &c., to prevent the possibility of panic through total extinction of the light. The generating station at Bercy was described in Abstract No. 1819 (1901), but many additions and modifications have since been made. The auxiliary dynamos consist of the exciter sets and boosters. The former are rotary transformers, two dynamos on the same shaft connected by an elastic coupling. They are each of about 65 kw. capacity, and transform the 600 volts down to 180 volts continuous; they are excited in shunt. The low-tension current serves to excite the alternators, and for the works lighting. The boosters, each of 200 kw., transform the generated continnous pressure from 0 to 25 volts, or continuously up to 150 volts, according as the battery is acting as a regulator or is being charged. The motors of the boosters are shunt excited, the generators being compound wound; the series winding is traversed by the full battery current; the shunt winding, connected to the bus-bars on the switchboard, through a rheostat, allows either of balancing the battery according to the pressure of distribution, or of raising the pressure for charging. The converter sets, each of 750 kw., consist of three static monophase transformers, 5,000 to 430 volts, and a rotary converting the alternating current at this latter pressure to direct current at 600 volts. The transformers are delta-connected on the primaries, the secondaries being independent; they are artificially ventilated. The rotaries have six rings on the alternating side, connected to sections on the armature 60° of phase apart. The speed is 250 r.p.m. They are started on the direct-current side; efficiency, 88 to 90 per cent. The battery is of 270 elements, and has a capacity of 1,600 ampere-hours at the one-hour rate; for twenty-four hours its capacity is trebled, and it can easily debit 3,000 amperes for short periods. *Converter Substation.*—The equipment here is similar to the converter equipment at the generating station, and transforms from 5,000 volts alternating to 600 volts direct current. One of the four sets is connected delta-wise on both sides, and runs at 300 r.p.m., but no difficulty on this score has been experienced in regard to paralleling. When the line was first operated the Bercy station was not ready, and a temporary supply of current was obtained, first from the Parisian Compressed Air Company (direct current) and later from the Moulineaux and Asnières Companies (5,000 volts, three-phase,

25 periods). Since November 1, 1901, to January 15, 1902, the Bercy station has been in operation, and has been sufficient for the requirements of the line. Since then, however, owing to the increase of traffic, it has been again necessary to call in the assistance of the Moulineaux and Asnières Companies; a new substation has been put down at the Louvre, to serve the part of the line between Bercy and the Étoile, and for the line between Bercy and Vincennes a feeder has been installed. *Generators.*—The capacity of the generating station at Bercy is now being increased, a 1,500-kw. three-phase generator set being in process of erection, with three new sets of 2,100 kw. on order. These are condensing plants, and by means of superheating, &c., it is hoped to obtain a consumption of 5 kg. of steam per i.h.p.-hour. Curves are given of the line current, the highest point touched being about 2,500 amperes, and also battery charge and discharge curves. On No. 1 line the number of trains running is as follows: 5.30 a.m. to 9 o'clock, 28 trains of from 4 to 7 coaches; 9 to noon, 26 trains of 4 and 5 coaches; noon to 3, 26 trains of 4 to 7 coaches; 3 to 8, 28 trains of 4 to 7 coaches; and 8 to half an hour after midnight, when the service ceases, 12 trains of 4 coaches. The rolling stock, as originally installed, consisted of units of 4 coaches, namely, a locomotive and three trailers. Each locomotive carried two series motors with spur gearing, each of 100 h.p., worked by a single series-parallel controller, with magnetic blow out; the usual safety devices, cutouts, fuses, and lightning arresters being provided. The collectors by which the current is picked up are carried by two connecting rods which permit of a certain freedom of movement both vertically and also sideways for negotiating curves. Owing to the increase of traffic it became necessary to be able at will to increase the size of the trains. This was effected by fitting each locomotive with controllers which will allow either two or four motors to be used at will, so that two of the original units can be worked together. The arrangement, designed by the Thomas-Houston Company, is described. The brakes are worked by compressed air, the compressors being operated by series motors at 550 volts. Tests were made, December, 1900, on a train of three coaches and one locomotive driven by two 100-h.p. Westinghouse motors. Starting from rest, with the motors in series, a speed of 6·5 m. per second was attained in 46 seconds, the current in the full-speed position being 150 amperes (at the twentieth second) and then dropping to about 75; the motors being then put in parallel, the current rose to 300 amperes at the fifty-seventh, dropping to 220 at the sixty-third second, by which time the speed had reached 9.5 m. per sec. The current being then shut off, the speed decreased uniformly to 6 m. per second at the hundredth second, when the brakes were applied and brought the train to rest in 5 seconds. The curves show that the energy lost in the resistances was 19 per cent. of the total consumption. The specific consumption is 49 watt-hours per tonne-km. A similar test made a year later gave the same result. For lighting, and for working the compressors, about 3 watt-hours must be added, giving a total of 52 watt-hours per tonne-km. This figure is somewhat high, but is reduced by increasing the tonnage of the trains, which is the present tendency. The total output of the generating station in direct current during December, 1901, was 1,047,568 units, of which 86·1 per cent. was for traction, and the rest for lighting. The total output per train-km. was 3,547 units, and 61 watt-hours per tonne-km. Comparing this with the actual consumption per tonne-km., viz., 49 watt-hours, the loss in the line is seen to be over 14 per cent. More recent tests give a loss of about 12 per cent. The signalling arrangements are worked electrically, on the automatic block system. Each train as it passes any signal

depresses a lever which actuates this signal, leaves the last one at danger, and re-sets the one before that at "line clear." There is also telephonic communication between all parts of the line. The paper concludes with a description, accompanied by a map, of the proposed extensions of the line. The estimated power necessary for the working of the line, including these extensions, will be 30,000 kw. three-phase. During the year 1901 the total number of passengers carried was over 48 millions, or more than 3¼ millions per km.

B. P. S.

993. *Hannawa Falls Electric Power System.* **W. C. Johnson.** (Amer. Soc. Mech. Engin., Trans. 23. No. 919. pp. 131–150, Dec., 1901.)—The author describes the hydraulic installation of the Hannawa Falls Water Power Company, which has acquired the land and water rights along the Raquette River, drawing its water from the drainage of the elevated forests of the Adirondack Mountains. The Raquette River drains an area of upwards of 1,100 square miles, and is further remarkable in that it has a drop of about 800 ft. in the first 8 miles of its course below Colton, and a further fall of 85 ft. in the next 2 miles of its course. The lower 85-ft. fall has been developed first. A dam has been built at the village of Hannawa Falls, which forms a pond 2½ miles long, and covering about 200 acres. From this pond the water is conducted by a canal about 2,700 feet long to a forebay, thence by penstocks to the wheels. The tailrace extends about 2,000 ft. down from the power-house, being separated from the river by an embankment of earth and stone. The location of the dam, forebay, power-house, and the general plan of the dam and entrance to the canal is shown by illustrations accompanying the paper, and a general description of the different parts and the materials used for their construction is given by the author. The dam was completed in 1899, and has had 4·5 ft. of water on its crest in two different seasons. The canal from the dam to the forebay, about 2,700 ft. in length, is 20 ft. in depth from the top of the banks, the bottom being 14 ft. below the crest of the dam. The bottom width of the canal is 30 ft., the top width 110 ft., making the inside slopes 2 to 1 in all cases. The section of the canal was made to carry 2,500 cubic ft. per second of water, with a velocity of 3 ft. per second, it being the intention to use that quantity of water when available. The canal ends in a forebay, in the walls of which there are embedded the ends of seven penstock pipes, six 10 ft., and one 6 ft. in diameter, leading down to the power-house on the bank of the river below. The power-house, which is 250 ft. long, and 60 ft. in width for one-half of the length, and 75 ft. for the rest, is two stories high, and has been built between the water of the river and the face of the high bank. The tailraces have been excavated so that the water in them stands 12 ft. below the floor when the wheels are running, giving a working head of 84 ft. on the wheels. The building is constructed entirely of Potsdam sandstone and steel. The lower floor of the building, a room 115 ft. long and 75 ft. in width, is the electric station, containing a 1,250-h.p. water-wheel, fed by a 6-ft. penstock as mentioned, to either end of which is direct-coupled a 350-kilowatt, three-phase, 4,400-volt generator. Underneath the north end of this room is one of the 10-ft. penstocks, in which there are three openings for receiving three wheels similar to the one described. To each of two of these wheels will be connected two generators similar to these now connected to the wheel mentioned ; the fourth will be provided with an extension shaft, to which will be belted an air compressor and other machinery. The water-wheel consists of two runners of American type on the same shaft, discharging outward. The

water is discharged through quarter turns and draught tubes to the tailrace. The speed is regulated by a Lombard governor geared directly to the gate rigging. The wheel and generators run at 850 revolutions per minute. The two 850-kilowatt generators are of the revolving field type, having 24 poles, and delivering three-phase current at a frequency of 60 periods per second and a pressure of 4,400 volts. The Hannawa Falls Water Power Company owns the electric lighting plant in the village of Potsdam, 4¼ miles from the station. A double line has been built, each line consisting of three cables of seven strands each of No. 10 aluminium wire. This line was figured to transmit 875 kilowatts with a drop of 400 volts, delivering 4,000 volts at Potsdam. The 20,000-volt line is intended to run to the village of Canton, 10¼ miles from the station, and thence to the city of Ogdensburg, 19 miles further. For lighting the station and local distribution 220 volts will be used. All of the lower floor of the power-house building not occupied by the electric station, and the whole second floor, will be occupied by a ground wood pulp mill of a capacity of 100 tons per day. The mill has been arranged for the purpose of utilising the spruce wood available in the region tributary to the Raquette River, and the great pulp wood district of the province of Quebec. The principal industry for which the Hannawa Falls Water Power Company are using the water power is the manufacture of wood pulp. The author describes fully the different manipulations and machines used in the manufacture, and the necessary precautions taken in order to ensure the regular supply of pulp at the rate of 100 tons per day as stipulated. In the grinder-room are placed two pairs of water-wheels of 8,500-h.p. capacity each, on horizontal shafts, supplied with water from two independent 10-ft. penstocks, and discharging into a common tailrace. A storehouse is located about 820 ft. from the power-house, and piling ground, sawing, and barking buildings are provided. The entire plant has been designed and built under the personal supervision of the writer of the paper. The paper is fully illustrated.

L. G

994. *La Goule Power Plant.* (Amer. Electn. 14. pp. 57–61, Feb., 1902.)—A description of a single-phase power and lighting plant on the French-Swiss frontier. The plant consists of three turbines of 500 h.p., and one of 650 h.p. built by Escher, Wyss & Co., and working under an effective head of 85 ft. 8 in. Their efficiencies are 79 per cent. at full load and 80 to 81 per cent. at three-quarter load. The alternators are coupled directly to the vertical shafts of the turbines, and generate at 5,500 volts, with a frequency of 50 cycles per second. The longest high-tension line is to the town of Renan, 12 miles distant. There are eleven substations in various towns, with distributing networks to the smaller villages. The charge for private lighting is 1·40 frs. per annum per candle-power, while, in factories, a charge of 10 frs. per annum is made for a 10-c.p. lamp. The charges for motors vary, according to size, from 536 frs. to 325 frs. or less per h.p. per annum.

A. E. L.

995. *Accumulator Substation at Milan.* (Elettricista, Rome, 11. pp. 33–39, Feb., 1902.)—The old steam generating station of St. Radigonda in Milan has been converted into a substation containing two large batteries of accumulators and rotary converters which take power from the three-phase transmission line from Paderno. The first battery supplies current at 550 volts for the Milan tramways, and has sufficient capacity to run the whole system for an hour. The second supplies at 125–135 volts for lighting purposes. The tramway battery is composed of 260 Tudor cells 192 R, and has a capacity of 3,464 ampere-hours for a one-hour discharge. The maximum discharge rate is 6,000 amperes. Each cell contains 12 positive plates, each of which is divided into two portions 35 × 78 cm. with a central support. The cell is 95 cm. long by 80 broad by 102 high, and weighs 2·2 tons.

The lighting battery is divided into four portions, each composed of 78 Tudor cells 256 R, and having a capacity of 4,624 ampere-hours for a one-hour discharge. The lighting is supplied on the three-wire system at 125 volts on each side. The two sides are, however, very unequally loaded, so that three of the batteries are joined in parallel on one side and the fourth on the other. Each cell has 16 positive plates of the same size and construction as those in the tramway battery. The dimensions are 95 × 108 × 102 cm. and the weight 2·6 tons. Each battery is in series with a booster by Thury, with automatic field regulation. G. H. B.

996. *Shawinigan Falls Electric Power System.* **W. C. Johnson.** (Elect. World and Engineer, 39. pp. 259–262, Feb. 8, 1902. Abstract of a paper read before the Canadian Society of Civil Engineers.)—These falls, on the St. Maurice River, are some 90 miles from Quebec and 84 miles from Montreal. A canal about 1,000 ft. long, 100 ft. wide and 20 ft. deep leads to the penstocks, which will be six in number, are 9 ft. in diameter, increasing to 11 ft. at a distance of about 50 ft. from the turbines, and are built of soft steel plates $\frac{3}{8}$ in. thick at the upper end and $\frac{9}{16}$ in. at the lower. The available head is nearly 130 ft., and the available h.p. seldom less than 200,000. Each penstock opens into the side of the case of a pair of "Francis" turbines on a horizontal shaft, capable of developing 6,000 h.p. and running at 180 r.p.m. The wheel-case is 16 ft. in diameter, with 81 ft. between the outside bearings. The runners, of gun-metal bronze, are 6 ft. in diameter, and discharge through a central draught tube. The guide-chutes are of cast steel. Where the penstocks enter the power-house they are held against movement from expansion and contraction, a cast-iron bracket, 12 in. deep, encircling the penstock and riveted to it, fitting closely on each side of the 6-ft. wall. Speed regulation is effected by means of gates in the draught tube, controlled by a hydraulic governor. The turbines will be stopped and started by means of a ring gate, on the outside of the guides, operated by an electric motor controlled from the switchboard gallery. Each turbine is coupled to a revolving-field generator capable of an output of 3,750 kw. at 2,200 volts, two-phase, with a frequency of 30. Exciting current is supplied to all the generators from a single dynamo driven by a pair of 500-h.p. turbines. A number of illustrations accompany the paper. G. W. DE T.

997. *Electric Plant at the Natural Food Factory, Niagara Falls, N.Y.* **A. B. Weeks.** (Elect. World and Engineer, 39. pp. 278–282, Feb. 8, 1902.)—Current is obtained from the Niagara Falls Power Co., at 2,200 volts, two-phase alternating. Two-phase induction motors are used for most purposes, but for the lifts, continuous current, transformed by means of rotary converters, is used. Stationary transformers reduce the pressure to 110 volts for lighting and 440 volts for power. A 1-ton electric crane is operated by means of three two-phase induction motors. Double-throw switches are used to reverse the motors. The machinery and processes employed in the manufacture of the principal product—the shredded wheat biscuit—are described, and fully illustrated by photographs and diagrams.

All heat for cooking is supplied by electricity. A miniature electric railway, for the purpose of serving luncheons to visitors, runs around the balcony of the main floor. It is equipped with tracks, switches, stations, and guards. On taking a seat at a station the visitor writes out an order, places it on the car, and presses a button. This lights a lamp on the switchboard in the kitchen. The switchboard operator closes the switch in connection with this station, when the car immediately proceeds to the kitchen. The order completed, the car automatically returns to the station from which it started, bearing the luncheon, and itself serves as a table for the convenience of the visitor. The block system is used, and accidents are not possible. F. B.

998. *Pont St. Martin Hydraulic Power Station.* (Elettricità, Milan, 21. pp. 87–91, Feb. 9, 1902.)—The station has been built by the Società Industriale Elettrochimica, with a view to the supply of power in the Canava and Biella valleys. Water is taken from the Dora Battea by a concrete dam 90 metres long, and a canal 800 metres long, and 16·8 square metres in section. The slope is 0·06 per cent., and the velocity of flow 1·8 metres per second. Four turbines by River Monneret & Co., with horizontal shafts are coupled directly to four three-phase generators by Schuckert. The pressure of 3,000 volts at the generator terminals is raised to 15,000 volts by transformers also by Schuckert. The pole line, consisting of six wires, transmits the power a distance of 30 kilometres, the line having, with its distributing branches, a total length of 70 kilometres. The pressure is reduced by transformers to 500 volts. G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

999. *Use of 45-feet Rails.* **T. R. Coates.** (Street Rly. Rev. 11. pp. 849–851, Nov., 1901. Paper read before the Roadmasters' and Maintenance of Way Association, Washington D.C., Oct. 1901.)—Practical use of rails longer than 30 ft. has been made on 34 out of 128 American railroads, the lengths varying from 31 to 62 ft. The majority of the rails are 33 ft. long, and represent a mileage of 14,000 miles. Thirty-three feet has been recommended by the above Association and by the *American Railway Engineering and Maintenance of Way Association*, as a standard. As regards cost, whereas one man can straighten a 30-ft. or a 33-ft. rail, it takes four men to handle a 60-ft. rail, and it is almost impossible to say whether it is straight or not. First cost, therefore, is greater with the 60-ft. rail. The cost of maintaining the joints is also greater in the case of the 60-ft. rail, owing to expansion and contraction. The 45-ft. rail reduces the number of joints by 33 per cent. of the number required for 30-ft. rails. If properly laid, special precautions having been taken to provide for expansion, a track with 45-ft. rails will ride better than one with 30-ft. lengths. The cost of lining and surfacing 45-ft. rails is slightly in excess of the cost with 30-ft., although there is a little saving in maintenance. F. B.

1000. *Chemical Treatment of Ties for Railroads.* **J. E. McNeil.** (Street Rly. Rev. 11. p. 846, Nov., 1901. Paper read before the Roadmasters' and Maintenance of Way Association at Washington D.C., Oct., 1901.)—The results are given of tests of the zinc-tannin or Wellhouse process of timber preservation. The object of the tests was to ascertain if the hardness of wood ties or the holding power of the spike were increased by the above chemical treatment. It was found that whilst the hardness of the wood was not increased, its density and transverse crushing strength were increased in proportion to the amount of chemical absorbed, which is about 30 per cent. in coarse-grained pine. The holding power of the track spike is also increased by 30 per cent. F. B.

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

1001. *Dangers from Trolley Wires.* **A. Jamieson.** (Inst. Elect. Engin., Journ. 31. pp. 76–89; Discussion, pp. 89–94, Dec., 1901.)—The Liverpool catastrophe proved that a wood strip fastened above the trolley wire is an inefficient guard against springy bronze telephone wires. The Board of Trade and Post Office regulations for guard wires are given. If faithfully carried out, with well-earthed wires, these regulations would give fair security against fallen wires, but the number of guard wires required is great, and their appearance objectionable. Guard wires and their bindings should be made of silicon bronze, instead of the usual galvanised steel: they would then be stronger, would have greater conductivity, and would resist the rapid atmospheric corrosion. The simplest provision for rendering sections of trolley line "dead" is an earthing switch in each car. The usual arrangement of locked switch pillars wastes much time. The only safe and sure plan to prevent dangers from wires falling on to the trolley lines is to place all non-tramway conductors underground, and use no guard wires. Appendices give particulars of tests of trolley and span wires, insulators, &c., supplied for the Glasgow Corporation Tramways.

Discussion.—**M. B. Field** considered that hitherto the telephone and telegraph engineers have used dangerously long spans. If a limit of 120-ft. span were fixed, the risk of breakage would be greatly minimised.
E. H. C.-H.

1002. *Prevention of Accidents on Electric and other Railways.* **S. S. Neff.** (Railroad Gazette, 34. pp. 52–53, Jan. 24, 1902.)—After discussing the various causes of accidents on electric railways, and means for preventing them, the author advocates the use of an automatic device for stopping trains when running past a signal at danger. This has been in use successfully for nearly a year on the Boston Elevated Railway [see Abstract No. 2337 (1900)], and comprises an arm or stop connected by linkwork to the signal, so that when the signal is brought to "danger" the arm will move into the path of a lever on the plug or spindle of an air-brake valve on the "train-pipe" of the car; if now the driver does not see, or neglects, the signal, the stop will strike the lever and move it so as to open the valve and stop the train. The cost of equipping a car is five dollars, and the cost of equipping each signal should not exceed 25 dollars. The paper is illustrated by photographs and drawings.
C. K. F.

1003. *Fenders for Tramcars.* **M. Kosch.** (Elektrotechn. Zeitschr. 23. pp. 84–88, Jan. 30, 1902.)—Fenders are divided into three classes: I. Fenders projecting in front of the car platform. II. Fenders arranged underneath the platform. III. Fenders with springs arranged to shoot forward on the release of a trigger by the motor-man. The merits and demerits of each class are discussed, particularly with reference to their ability to safely take up a person *standing* on the permanent way, or lying with his body in the direction of motion. For these cases no one of the three classes is considered entirely satisfactory. The fender, of Class I., adopted on the Berlin tramways, is described and illustrated by a sketch. A. E. L.

1004. *Electric Lifts of the City and South London Railway.* (Tram. Rly. World, 11. pp. 13–16, Jan. 9, 1902.)—The article describes fully the construction of the lift cages, the motors and hoisting gear, the switch gear and the safety devices. The efficiency from the motor input to the load hoisted is about 50 per cent. The article contains five illustrations and diagrams. G. H. B.

1005. *Railway Signalling.* **I. A. Timmins.** (Proceedings of Section I. of the International Engineering Congress, Glasgow, pp. 22–32, 1902.)—The author deals with modern developments in the practice of railway signalling. Hydraulic systems are failures. Pneumatic systems are operated on either high or low pressure. The Westinghouse system may be taken as a type of the former, the pneumatic pressure being controlled by electrical means. Both are fully described. Of electrical systems, the earliest were worked by primary batteries, which supplied current to small motors. Such, for instance, was the method of the Union Switch and Signal Company of America. A further development introduced the use of secondary batteries. The first automatic electric system of signalling was fitted by the author on the Liverpool Overhead Railway, the signals being operated by long-pull electromagnets, actuated by the passing train. At the Paris Exhibition an automatic system was fitted, covering two miles of line, similar in general outline to the Liverpool system. The methods of electric signalling adopted at Crewe are finally described. All the systems above mentioned are explained in detail, and all are further illustrated by drawings. It takes considerably less than a second to lower a signal by electricity or to move and lock a pair of points by electromagnets. Pneumatic signals at 500 yards distance take 9 or 10 seconds to complete the return current, and it is not practicable to work signals at 1,200 yards except by electrical means. W. H. S.

1006. *Use of Recording Instruments on Railways.* **C. Jacquin.** (Écl. Électr. 30. pp. 17–28, Jan. 4, and pp. 81–88, Jan. 18, 1902.)—The author gives the results of his experiments with recording apparatus used on the trains of the Paris, Lyons, and Mediterranean Railway, which are lighted electrically. His main object was to discover means by which the vibration of the train might be neutralised, and to ascertain the extent to which this vibration affected the accuracy of the results or the calibration of the instrument. Some instruments by Richard were first used with a dashpot consisting of a rod, 2 mm. in diameter, plunging in glycerine [see Abstract No. 1937 (1901)]. This proved wholly insufficient, the jolting of the train producing a trace of such breadth that nothing could be distinguished. At the end of the rod, therefore, a piston 20 mm. in diameter and 0·5 mm. thick was fixed and made to plunge in a cylinder 25 mm. in diameter filled with glycerine. This blotted out oscillations of every kind, including the variations of voltage which the instrument was intended to register. The piston was therefore pierced with four holes, each of 2 mm. diameter, and a good record was then obtained. A similar result was obtained on diluting the glycerine with water. The instrument was placed in a cupboard in one of the carriages, and suspended by strong rubber bands, which were tightly stretched and fastened to the floor and roof of the carriage. These rubber bands were intended to damp out any very violent oscillation; but unless they were very tightly stretched they were found to be useless. Moreover, the calibration of the instrument was found to be affected, and this was probably due to the effect of the vibration on the springs actuating the pointer. Some further experiments were carried out with a registering voltmeter by Meylan, which gave good results when properly adjusted. Curves given by the two instruments under the different conditions are reproduced. W. H. S.

1007. *Electrolysis by Earth Returns.* **E. B. Ellicott.** (West. Soc. Engin., Journ. 6. pp. 529–536; Discussion, pp. 536–548, Dec., 1901.)—A general discussion of the question, and a recommendation to obtain a uniform p.d. between rails and pipes (or only a small variation over a given distance), so as to distribute any destruction uniformly, thus making it negligible. Where there is a marked variation of p.d. there is generally a serious disintegration. On that account the Council of Chicago has passed an ordinance requiring that earthed returns should be so constructed that a greater p.d. than 8½ volts should not exist at any point between the water-pipes and rails, and the variation between any two points within 300 ft. should not exceed half a volt.

Discussion.—**McCulloch** pointed out that the current flowing did not depend only on the p.d., but also on the conductivity of the earth at any point, which may vary considerably. Consequently the method suggested is difficult to apply. He described the way in which his Company prepared contour maps to determine the electrical condition of the tramway area. The surest remedy is good bonding and return feeders. Cast welded joints can be guaranteed to have 99 per cent. conductivity of the rail if properly made. **W. E. Foss** gave diagrams showing how the potential of the rail and also of the pipe varies with the distance from the power station in the case of the Metropolitan District (Boston). According to his experience, injury is due chiefly to local favourable conditions, and is most severe at the sharp edges of pipe bells and at a line about 2 ft. on either side of the pipe joint. On account of the rapid variation of p.d. with traffic, there would be difficulty in deciding whether the Council Ordinance is complied with. **Ellicott,** in reply, stated that the conductivity of the earth in Chicago did not vary more than 20 per cent. He described the method of measuring the resistance when a p.d. exists, which consists essentially in allowing an opposing current to flow of such a value that a p.d. is set up equal and opposite to the orginal p.d. [See also Abstract No. 1596 (1900)]. W. R. C.

1008. *Magnetic Field Produced by the Paris Electric Tramways.* **T. Moureaux.** (Annal. Chim. Phys. 25. pp. 139–144, Jan., 1902.)—An account has been given [see Abstract No. 618 (1902)] of the author's investigations at the observatories Parc Saint-Maur and Val-Tayeux. In this paper further comparison is made between the two stations, of which one is, and the other is not, affected by electric tramway working. By suitable damping of the needles the author strives to bring the readings at the two stations more and more into agreement. P. E. S.

1009. *Reduction of Earth-Current Losses on Electric Railways.* **E. Ziehl.** (Elektrotechn. Zeitschr. 23. pp. 145–147, Feb. 20, 1902.)—The author describes a series of experiments made by him, in order to prove that the earth-current losses can be considerably reduced, when either single or polyphase alternating current is used for the working of railways which have the rails as returns. Following G. Kapp's suggestion (see Elektrotechn. Zeitschr. 23. Jan. 2, 1902), the author inserts in the circuit as a "booster" a transformer connected in such a manner that the primary is joined in series to the wire conducting the current to the motor, and the secondary is connected to the rails. In the author's experiments the assumption was made that the transformer was placed in the middle of the rail, but so arranged that the rail resistance, transformer and earth resistances are put in series. In practice, however, the transformer will have to be put where the potential difference between the rail and earth is zero, or nearly so, and that without the use of the transformer as a booster. The author used in his trials an alternating current of 50 ∿, and the voltage was kept constant at 215 during the trials. In testing the earth-current losses without the use of the booster, the author found them to be about 10 per cent. of the current passing the rails as return, but with the aid of the transformer arranged as suggested he found the losses to be very considerably reduced, by simply altering the ratio of ampere-turns of the primary and secondary windings of the transformer used. In the experiments made, the best ratio (by which the losses were reduced by about 70 per cent.) was 1·08, the primary winding having 55 turns, and the secondary 51 turns. The author tabulates all the results obtained, and also gives them diagrammatically, by which it is seen that there exists a close relation between the earth current and the current used on the line. The conclusions arrived at by the author are: that in inserting in series a transformer as a booster in the manner indicated, the earth-current losses can be made to be positive, negative, or zero, and therefore the suggestion made by G. Kapp, of introducing single or polyphase transformers as boosters is shown to be a good one, and static transformers are convenient in use, owing to their not requiring much attention. L. G.

ELECTRIC LAMPS AND LIGHTING.

1010. *Glow Lamps on Alternate-current Circuits.* **P. Janet** and **C. Léonard.** (Soc. Int. Élect., Bull. 1. pp. 615–635, Dec., 1901.)—The author in a previous paper deduced formulæ for the above [see Éclairage Élect. 11. p. 507 (1897)]; from which it appears that for a 100-volt 16-c.p. lamp, at a frequency of 40, the extreme values of the c.p. were 14·1 and 18·5, or 13·7 per cent. from the mean, and the lag 43°·7, reckoning the half-period, since the frequency of this quantity is twice as great as that of the alternating current considered. The results thus obtained theoretically were tested experimentally by M. Léonard. The method employed consisted in measuring the intensity of the light through two diametrically opposite segmental slits in a rotary disc, driven by a bipolar synchronous motor which is supplied with current from the same mains as the incandescent lamp under test, so as to always expose the lamp to the photometer at the moment when the difference of potential has the same value. The slits in the disc are each of a width equal to $\frac{1}{16}$th of the circumference, and the disc is divided into sixteen equal sectors, to enable sixteen values of the intensity to be obtained when there is a single slit. The shaft is provided with a pointer which can be set to any of these sectors. The potential difference and current at the moment of measuring the intensity of the light were determined by Joubert's method. The variations with a 18·7-c.p. (bougie decimale) 110-volt lamp, with a current of frequency 42, were from 12·85 to 15 c.p. The influence of the frequency, of the mass of the filament, and of the form of the curve of differences of potential of the alternating current on the variations in the intensity of the light were also examined. The author also deduces from the curve of intensity of light the variations in the power dissipated by the filament at the same time, and also the variations in the amount of heat-energy stored up in the filament during the same time. The paper is illustrated by a diagram of connections and curves giving the results of the experiments made. C. K. F.

1011. *Rosemeyer's "Regina" Arc Lamp.* (Elekt. Runds. 19. pp. 84–85, Jan. 15, 1902.)—In this lamp there is a special gas-check, not described, and the carbon-feed is effected by means of a clutch comprising three rings which, when acted upon by the core of the controlling electromagnet, slide on inclined surfaces, and are thus forced together to hold the carbon. The lamp will work at 110 volts with a direct current of 5 amperes. At 100 volts the arc is 7 to 10 mm. long, and the light is emitted throughout an angle of 120°. Tests made by W. Wedding, of Charlottenburg, gave a consumption of current of 1·075 watts per Hefner candle. The lamp burns 160 hours with one set of carbons. The spectrum is very similar to that of sunlight. C. K. F.

REFERENCES.

1012. *The Conservation of Energy from the Engineer's Standpoint.* **Kammerer.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1750–1754, Dec. 7, 1901. Paper read before the seventy-third meeting of the German Naturalists and Physicians at Hamburg.)—Gives examples of energy transformations in engineering cases with the help of load diagrams. W. W. H. G.

1013. *Fault-Finding in Networks.* **P. Charpentier.** (Écl. Électr. 26. pp. 365–370, March 9, 1901.)—The bridge method is used, and applied to complicated networks. The originality of the method consists in making a single measurement to find the fault in a defective section. The method is applicable to a fault between conductors when at least one conductor is not to earth. M. O'G.

1014. *Design of Transformer Substations.* **F. Winawer.** (Zeitschr. Elektrotechn., Wien, 19. pp. 621–624, Dec. 22, 1901.)—The author discusses the design of transformer substations, both underground and above ground, on the Continental kiosk pattern. The safe handling of the switch-gear and convenient arrangement of connections are also discussed. E. K. S.

1015. *Electricity Supply Works Costs in* 1899 *and* 1900. (Electrician, 48. pp. 410–418, Jan. 3, 1902.)—An article summarising the more interesting results of analyses of electricity supply works published during 1899 and 1900, with curves showing average costs for each of the years 1896–1900. G. W. DE T.

1016. *Transit Problems and Electric Traction on Railways.* **W. Langdon.** (Inst. Elect. Engin., Journ. 31. pp. 253–278; Discussion, pp. 279–281, Feb., 1902. Presidential Address.)—An appendix to the address gives some interesting statistics relative to the present use of electricity for light and power purposes on existing steam railways. G. W. DE T.

1017. *The Incandescent Lamp.* **J. W. Howell.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 923–925, Dec., 1901.)—This paper contains a brief description of the main applications, characteristic features, properties, and methods of using modern incandescent lamps. C. K. F.